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EVALUATION AND ASSESSMENT OF UNAMAP

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The Evaluation and Assessment of UNAMAP is a study to determine how best to improve the usefulness and availability of the UNAMAP air pollution dispersion models. This report describes a plan for implementing a series of recommended improvements to the UNAMAP program. It also describes the earlier parts of the study upon which the plan is based. The study consisted of a technology assessment followed by data collection and analysis which were used to develop the strategy and the specific improvements contained in the plan. The overview includes a summary of the data collected during the study, and the conclusions drawn from analysis of that data. The analysis indicates that improvements to UNAMAP are needed in the areas of: 1) model accuracy, 2) model documentation, 3) user support, 4) data collection, 5) data input, and 6) computer compatibility. The report describes a plan which is based on a strategy that is consistent with the longterm objectives for UNAMAP. The report contains a strategic framework for improving UNAMAP. This strategic framework guides the implementation and strikes a balance between the goals of advancing dispersion modeling research and transferring technology to the public. Included in the plan is a set of ten specific recommended improvements which are described and broken into specific tasks. Estimates of time and cost required to implement each improvement are given at the task level. Finally, the recommended improvements are grouped into three phases. A schedule is presented at the task level for the five recommended improvements in Phase 1.

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EVALUATION AND ASSESSMENT OF UNAMAP

PART I: PROJECT SUMMARY

February 1988

EVALUATION AND ASSESSMENT OF UNAMAP
PART I: PROJECT SUMMARY

INTRODUCTION

The User's Network for Applied Modeling of Air Pollution (UNAMAP) is a software library of air quality simulation models provided by the Environmental Operations Branch (EOB) of EPA's Atmospheric Science Research Laboratory (ASRL). The Evaluation and Assessment of UNAMAP project was designed to facilitate EOB's ongoing efforts to improve the utility and availability of UNAMAP to the public.

The results of the study describe a plan for implementing a series of recommended improvements to the UNAMAP program. The plan consists of a definition of strategy consistent with EPA's objectives for UNAMAP, and the schedule and budget to implement the specific recommendations.

The improvements were derived during the course of the investigation, and were based on two major sets of requirements. Technology requirements determine what computer, data, and modeling technology are available to UNAMAP users now and in the near future. User requirements determine what areas of UNAMAP utilization are most difficult and determine where improvement would be most beneficial. Each recommendation has been formulated both to take advantage of the current technological environment and to help meet expressed and implied user requirements.

The conclusions and recommendations in this study are based on research and analysis which were performed in three phases. The first was a technology assessment to determine technology available to UNAMAP. The second was data collection (by interview and questionnaire) and analysis. The third was the derivation of recommendations.

TECHNOLOGY ASSESSMENT

All products follow a pattern of growth which involves changes to the product, the users, and the market. UNAMAP has followed such as growth pattern. The Technology Assessment Report evaluated the technological environment in which UNAMAP exists today and that in which it will function most effectively in the future. The information was used in subsequent stages of the project to provide evaluation criteria for system alternatives and final recommendations.

The technology assessment found that all components of modeling technology have changed dramatically since the development of the first computerized air quality models in the 1960's. The technology is continuing to change at a fast pace. The report covered three distinct phases in air quality model development: (1) the technology as utilized by UNAMAP Version 6; (2) the technologies used by models currently under development, as well as adaptations made to UNAMAP to utilize current technology; (3) the technological requirements for future models to solve current problems.

In Version 6, the technology applied to the models has progressed, while that of the computer systems used to run them at EPA has not. Although the original Gaussian dispersion mathematics are still used, the UNAMAP models have become more sophisticated and consistent. Adaptations and new processors have increased the models' usability. The UNIVAC 1100 utilized for support, however, represents no advances since UNAMAP was begun in 1973.

New modeling developments have grown from the user community's attempts to deal with today's air quality modeling applications. Model developers are creating models for more challenging environmental problems. UNAMAP users have adapted the models to respond to situations that are different or more complex than those for which the software was designed. Consultants and third-party vendors have contributed more sophisticated data collection and input methods and facilitated the use of new computer technology.

Modeling software must advance to meet both application and user needs. Modeling has become a successful and important tool in protecting the environment. Because of this success, models are needed for even more complex, real-world situations which need representation. Complex regional models are needed by county, regional, and state agencies to study dispersion and transport of pollutants over larger distances. More realistic complex terrain models are needed to represent geographical areas where terrain is a factor.

The typical model user has changed since the advent of UNAMAP. Today, a user may not be a "modeling expert." He may use the models only a few times a year or lack the computer expertise to use mainframe versions easily. Services such as modeling consultants and developers of menu-based microcomputer versions have grown to meet the needs of today's user.

Users expect software which not only fits the application, but is also easier to use. In judging ease of use, the user-friendly, microcomputer products available for other applications will be used as criteria against which the UNAMAP software will be judged.

The data used by the models will continue to be provided by the National Weather Service (NWS) or collected at the site in question. Therefore, more consistency of data input and output among the models will be needed to accommodate the novice or infrequent user.

Computer technology will continue its trend toward distributed processing with microcomputers used for an increasing amount of modeling activity, including graphics output. User expectations will also require that data gathering and file transfer technologies in UNAMAP match those available in other application areas.

DATA COLLECTION AND ANALYSIS

A major portion of the Evaluation and Assessment of UNAMAP project was the collection of data from UNAMAP users and other members of the dispersion modeling community. The data helped define who uses UNAMAP and how the models are used. The data also identified the areas of the modeling process which users felt should be improved.

There were two parts to the data collection activity: personal interviews and mailed questionnaires. In-depth interviews were conducted with 22 representatives of the following organizations:

- EPA (ASRL and OAQPS)
- EPA Regional Meteorologists
- State air quality agencies
- Local or county air quality agencies
- Private industries (as users of the models)
- Educational institutions
- Modeling consultants
- Modeling software marketers

The interviews provided an overview of the UNAMAP system as well as information on the modeling process. The data from the interviews were used to design a questionnaire which was mailed to a larger segment of the UNAMAP community (256 organizations).

Usable data were returned in 112 questionnaires. These questionnaires were analyzed, and certain types of data were extracted including a user profile, which models are used, and problems encountered in the modeling process. A typical UNAMAP user:

- Belongs to one of four major industry groups: consultant, state government, private industry, or local government;
- Classifies himself as a user of the models;
- Has an experience level which varies by industry group.

The largest portion of the questionnaire dealt with the problems perceived by the users and their suggestions for improvement. Twelve potential problem areas were identified by Battelle project team members based on conversations with EPA. Questionnaire respondents were asked to rank the problem areas as to the severity of the problem. User responses were grouped into low, medium, and high categories. Problem areas scored as medium or high on the severity scale by all major user groups were further analyzed. User suggestions to correct these problems were categorized, and a percentage of suggestions in each category was computed.

Six out of the original twelve potential problem areas were rated as major problems by the users. These are the problems which Battelle's recommendations attempt to rectify.

The following table shows the areas specified as major problems as well as the potential problems not considered significant by most users:

PROBLEM AREAS

MAJOR PROBLEM	NOT A MAJOR PROBLEM
Accuracy of the models	Choosing a model
Documentation of models	Buying/accessing the model
Support for models	Hardware access
Data collection	Unreliable hardware
Data input	Response time
Hardware compatibility	Other (users could specify problems not listed)

Alternatives were generated from the suggestions and from typical components of technical support in the informations systems industry. Evaluation criteria and constraints were identified, and used to determine the strengths and weaknesses of the alternatives.

The suggestions and alternatives were evaluated using the technological context described in the Technology Assessment and industry experiences with currently implemented systems as described in the trade literature. Through the evaluation process, Battelle developed a list of recommendations. The recommendations were formulated to address multiple problem areas wherever practical, and to utilize technology which is available to the UNAMAP support staff and model users.

RECOMMENDATIONS

The UNAMAP program has great visibility and impact on the public, including industry, state air pollution control agencies, and community groups. To take advantage of this visibility, UNAMAP needs to provide a centralized modeling service of high quality. The recommended improvements, when taken as a whole, will allow UNAMAP to achieve the following goals:

- To function as the public source of newly developed and refined air quality models.
- To distribute models which are easily executed on a variety of commonly-used computers of all sizes.
- To provide a wide set of models which are relatively easy to execute, even for the novice or occasional user.
- To offer modelers a central source of technical information, meteorological data, and user support.

To attain these goals, a long-range strategy and milestones are required. Therefore, the first part of the implementation plan is a strategic framework. This serves as a guideline for the assignment of priorities to the recommendations. The priorities are consistent with the long-term objectives of the UNAMAP program. The strategy is designed to strike a balance between the two objectives of UNAMAP: advancement of research in dispersion modeling, and the effective transfer of modeling technology to the public.

The approaches discussed will first expand the users' ability to use the models, and then serve to advance the modeling technology being used. The initial changes must allow UNAMAP to evolve to meet the current expectations of the modeling community. When using the regulatory models is less difficult, modelers will be able to turn more of their attention to the research aspects of modeling. As in the early days of UNAMAP, the user community will become more involved in the process of testing and validating new models as part of the research cycle.

The strategy can be executed through a set of ten specific recommendations for improvement to UNAMAP. They are the following:

- Establish an electronic bulletin board on a multi-user computer system.
- Provide a set of end-user documentation for all UNAMAP models.
- Provide models which execute on IBM mainframes, DEC VAX computers, and IBM PC's.
- Improve the accuracy of models.
- Develop consistent user-friendly interfaces for all models.
- Consolidate all support for all UNAMAP models.
- Establish a meteorological data clearinghouse.
- Include more special purpose models in UNAMAP.
- Support the collection and use of additional and more accurate meteorological data.
- Support the electronic distribution of UNAMAP documentation and updates.

The report summarizes each recommendation, and discusses implementation tasks and estimated costs.

Based on its contribution to the strategic framework, each improvement can be assigned a priority and a completion time estimate. These two factors are used to generate an implementation schedule and a budget.

Battelle's implementation plan estimates that the five recommendations grouped into the first phase of improvements can be implemented over a schedule of 121 weeks for an estimated cost of $769,000. These are preliminary figures based on current understanding of the work required. The cost estimates are over and and above the current EOB budget and are predicated on contracting for all model enhancement and documentation work. EOB resources would be reallocated to perform on-going management functions generated by the recommendations.

EVALUATION AND ASSESSMENT OF UNAMAP

PART II: TECHNOLOGICAL ASSESSMENT

November 1987

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EVALUATION AND ASSESSMENT OF UNAMAP
PART II: TECHNOLOGY ASSESSMENT

1.0 INTRODUCTION

1.1 Purpose

In 1973, The Environmental Protection Agency began making air quality simulation models available through the User's Network for Applied Modeling of Air Pollution (UNAMAP). Since then, models have been added and deleted from the UNAMAP set. Certain preprocessors and postprocessors have been added. Originally available only on a UNIVAC 1100 computer, the models have been converted by users to run on a variety of other computers. The purpose of this report is to assess the technology utilized by UNAMAP and to project the technological environment in which UNAMAP will function most effectively in the future. The information will be used in the subsequent stages of the Evaluation and Assessment of UNAMAP, and will provide evaluation criteria for system alternatives and final recommendations.

1.2 Organization

This report is organized into three main sections, each representing a distinct phase in air quality model development. The first section will discuss the technology as it is utilized by UNAMAP Version 6. The second section will describe the technologies being used by models currently under development, and will address the adaptations being made to UNAMAP to utilize current technology. The third section will project the technological requirements for models which will be needed to solve the current problems facing air pollution meteorology and pollution control professionals.

Each section will address three technological components of an air quality modeling system: the modeling software, the meteorological and emission source data, and the computer system. The modeling software is the computer programs which incorporate physical, chemical, meteorological, and statistical principles to predict the dispersion of air pollutants under historical meteorological conditions. Each section of the report (Version 6, new developments and adaptations, and emerging technologies) will describe the modeling technology to be supported.

A variety of meteorological and emission data are required for the UNAMAP models. The meteorological data required by the modeling software typically include hourly readings of weather conditions. The data may be collected either at the site to be modeled, or at the nearest climatologically similar, first-order National Weather Service weather station which is generally an airport or a military airbase. The emission or source data may include an inventory of other air pollution sources in the area, measurements of proposed stack dimensions, and engineering calculations on the volume of emissions to be released by the facility. Each section of the report will address the technological trends and requirements for these types of data.

The computer system technology related to UNAMAP includes processing, communications, and graphics. Computer processing is the ability to manipulate the modeling programs and data. Particularly important to UNAMAP are the areas of FORTRAN compilers, processor speed for performing large numbers of floating point calculations to the required number of significant digits, and cost of executing the model. Communications technology assessment will focus on the ability to access remote computers or to transfer data and results from one location to another. Graphics technology will be assessed to determine how hardware and software can provide flexible display capabilities for the UNAMAP models.

Since the development of the first computerized air quality models in the 1960's, all components of the technology have changed dramatically. Furthermore, they are continuing to change at a fast pace. This report will concentrate on the differences in technology from one phase of model development to the next.

2.0 UNAMAP VERSION 6 TECHNOLOGY

This section addresses the modeling and computer technology utilized by the publicly available, EPA-supported version of UNAMAP. An overview of the contents of Version 6 and the rationale for the inclusion of these models is followed by a description of the modeling and computer technology employed.

2.1 Contents of Version 6

Models acceptable for use in federal regulatory actions are listed in the Guidelines on Air Quality Models (Revised) (EPA, July, 1986). The Guideline models are divided into two categories:

- Appendix A models which are preferred for specific regulatory applications.
- Appendix B models which are acceptable for regulatory applications under special circumstances

UNAMAP Version 6 contains 24 different dispersion models, a variety of pre- and post-processors for the models, and test input and output data for each model. UNAMAP includes models from both Appendix A and Appendix B as well as some non-Guideline models.

Originally, UNAMAP contained only the dispersion models, but Version 6 contains several processor programs which enhance the utility or capabilities of the models. Processors are available for formatting meteorological data to meet the model requirements, calculating running averages, plotting concentrations on a grid, and eliminating the influence of calm conditions on pollutant dispersion.

Version 6 contains two types of models: 1) those for regulatory use and 2) newer models provided for inspection and evaluation. The selection of models and supplementary programs included in UNAMAP varies from version to version to reflect the needs of modeling applications. A variety of screening and evaluation models are included to meet the requirements of many air pollutant dispersion problems.

2.2 Modeling Technology in Version 6

2.2.1 Air Pollution Meteorology

UNAMAP Version 6 contains numerous models because there is no all-purpose model which is practical to use. The models differ in their ability to handle the various aspects of the modeling process such as:

- type of pollutant being emitted and dispersed,
- distance at which concentrations can be predicted,
- height of points where concentrations can be predicted (relative to height of source),
- number and type of pollution sources,
- averaging time of estimated concentrations (short term or long term).

However, some of the models actually perform duplicate functions. Some agencies or groups advocate the use of one of these duplicate models over another.

As mentioned earlier, UNAMAP Version 6 includes both Guideline and non-Guideline models. Seven of the eight Appendix A models are in Version 6. The one model not included is the Urban Airshed Model (UAM) which, due to its large size, was excluded from the UNAMAP tape, but is available separately from NTIS. A comparison of UNAMAP to Guideline models can be made from the following series of four tables showing properties and capabilities of the various models. Appendix A UNAMAP Version 6 models are listed in Table 1. Table 2 represents Appendix B UNAMAP models, and Table 3 contains the UNAMAP models which are not included in the Guidelines. Table 4 lists those Guideline models not in UNAMAP. In these tables, the phrase "primary pollutants" refers to those pollutants which, for the purposes of modeling, will not undergo chemical transformations in the atmosphere.

TABLE 1. UNAMAP MODEL OPERATION CHARACTERISTICS

Guideline Models - Appendix A

	Model Acronym	Model Type	Pollutant Types	Plume Rise Treatment	Downwash Treatment	Chemical Transformation	Physical Removal	Wind Speed Profile Treatment	Urban or Rural?
Guideline Models Appendix A	BLP	G.P.	Prim.	S&S	Building	Linear decay	No	Exp.	Rural
	CALINE3	G.P.	Prim.	No	No	No	Deposition & settling	No	Either
	CDM	G.P.	Prim.	Briggs	Stack	Exp decay	No	Exp.	Urban
	CRSTER	G.P.	Prim.	Briggs	Stack	Exp decay	No	Exp.	Either
	ISCLT	G.P.	Prim.	Briggs	Stack & bldg.	Exp decay	Deposition & settling	Exp.	Either
	ISCST	G.P.	Prim.	Briggs	Stack & bldg.	Exp decay	Deposition & settling	Exp.	Either
	MPTER	G.P.	Prim.	Briggs	Stack	Exp decay	No	Exp.	Either
	RAM	G.P.	Prim.	Briggs	Stack	Exp decay	No	Exp.	Either

Legend

Appendix A = Appendix A of EPA Guideline on Air Quality Models (1986)
Briggs = Briggs (1969, 1971, 1975) plume rise equations
CBM-II = Carbon-Bond II Mechanism
exp. = exponential

exp decay = exponential decay
G.P. = Gaussian Plume
Prim. = Primary
S&S = Schulman and Scire (1980)

TABLE 1: GUIDELINE MODELS - APPENDIX A

TABLE 2. UNAMAP MODEL OPERATION CHARACTERISTICS

Guideline Models - Appendix B

	Model Acronym	Model Type	Pollutant Types	Plume Rise Treatment	Downwash Considered	Chemical Transformation	Physical Removal	Wind Speed Profile Treatment	Urban or Rural?
Guideline Models Appendix B	APRAC-3	G.P.	Prim.	No	No(1)	No	No	No	Urban
	HIWAY-2	G.P.	Prim.	No	No	No	No	No	
	LONGZ	G.P.	Prim.	B&B	Stack	Exp. decay	Dep. & settling	Exp.	Either
	MESO PUFF II	Gaussian puff superposition	SO_2, SO_4, NO_x, HNO_3	Briggs	No	Rate constants	Dep. & wet removal	Specified	Rural
	PAL-2	G.P.	Non-react.	Briggs	No	No	Settling & dry dep.	Exp.	Urban
	SHORTZ	G.P.	Prim.	B&B	Stack	Exp. decay	Settling & dep.	Exp.	Either
	PLUVUE	G.P.	TSP. NO_x, SO_2, H_2SO_4, O_3	Briggs	No	9 reactions	Dry dep.	No	Either

Legend

Appendix B = Appendix B of EPA Guideline on Air Quality Models (1986)
B&B = Bjorklund and Bowers (1982)
Briggs = Briggs (1969, 1971, 1975) plume rise equations
CBM II = Carbon-Bond II Mechanism
dep. = depositon

G.P. = Gaussian Plume
exp decay = exponential decay
Prim. = Primary
non-react. = non-reactive
exp. = exponential

TABLE 2: GUIDELINE MODELS - APPENDIX B

TABLE 3. UNAMAP MODEL OPERATION CHARACTERISTICS

Non-Guideline UNAMAP Models

Model Acronym	Model Type	Pollutant Types	Plume Rise Treatment	Downwash Considered	Chemical Transformation	Physical Removal	Wind Speed Profile Treatment	Urban or Rural?
INPUFF	G.P.	Prim.			No	Deposition & settling		
PEM-2	G.P.	Prim.	Briggs		First order decay	Deposition & settling		Urban
TUPOS 2.0	G.P.	Prim.	Calculated from wind & temperature profile	No	No	No	User furnished	
PBM	Box	Photo-chemical	Homogeneous distribution throughout box	No	63-step kinetic mechanism	No	No variation with height	No dispersion coefficients are used
PTPLU-2	G.P.	Prim.	Briggs	Stack	No	No	Exponential	Either
MPTDS	G.P.	Prim.	Briggs	Stack	Pollutant decay	Deposition & settling	Exponential	Rural
ROADWAY-2.0	Finite - difference	Photo-chemical			Yes		Similarity theory	

Legend

B&B = Bjorklund and Bowers (1982)
Briggs = Briggs (1969, 1971, 1975) plume rise equations
CBM-II = Carbon-Bond II Mechanism
dep. = depositon

G.P = Gaussian Plume
exp decay = exponential decay
Prim. = Primary
non-react. = non-reactive
exp. = exponential

TABLE 3: NON-GUIDELINE UNAMAP MODELS

TABLE 3. UNAMAP MODEL OPERATION CHARACTERISTICS

Non-Guideline UNAMAP Models
(continued)

Model Acronym	Model Type	Pollutant Types	Plume Rise Treatment	Downwash Considered	Chemical Transformation	Physical Removal	Wind Speed Profile Treatment	Urban or Rural?
VALLEY	G.P.	Prim.	Briggs	No	Pollutant decay	No	None	Rural
COMPLEX-I	G.P.	Prim.	Briggs	No	No	No	None	Rural

Legend

B&B = Bjorklund and Bowers (1982)
Briggs = Briggs (1969, 1971, 1975) plume rise equations
CBM-II = Carbon-Bond II Mechanism
dep. = depositon

G.P. = Gaussian Plume
exp decay = exponential decay
Prim. = Primary
non-react. = non-reactive
exp. = exponential

TABLE 3, CONTINUED: NON-GUIDELINE UNAMAP MODELS

TABLE 4. MODEL OPERATION CHARACTERISTICS

Guideline Non-UNAMAP Models

	Model Acronym	Model Type	Pollutant Types	Plume Rise Treatment	Downwash Considered	Chemical Transformation	Physical Removal	Wind Speed Profile Treatment	Urban or Rural?
Appendix A:	UAM	3-dimensional numerical, photo-chemical grid	O_3	Briggs	No	CBM-II	Deposition	Specified	Urban
Appendix B:	AQDM	G.P.	Non-react.	Briggs	No	No	No	No	Rural
	ARRPA	Gaussian Segmented Plume	SO_2 & SO_4	Piece-wise continuous	No	Rate constant	Dep.	Model-predicted	Mixture
	COMPTER	G.P.	Prim.	Briggs	No	No	No	Exp.	Either
	ERTAQ	G.P.	Prim.	Briggs	No	Exp. decay	Dep	Exp.	Either
	GMLINE	G.P.	Prim.	Heated exhaust	No	No	No	No	Not specific
	IMPACT	Eulerian finite difference	SO_2, SO4, NO_x, NO_2, O_3	Briggs	No	Species mechanisms	Exp. decay	Specified	Not specific
	MPSDM	G.P.	Prim.	Briggs	Stack	No	No	User designated	Not specific

Legend

Appendix A & B = Appendix A or B of EPA Guidelines on Air Quality Models (1986)
B&B = Bjorklund and Bowers (1982)
Briggs = Briggs (1969, 1971, 1975) plume rise equations
CBM-II = Carbon-Bond II Mechanism
dep. = depositon

G.P. = Gaussian Plume
exp decay = exponential decay
Prim. = Primary
non-react. = non-reactive
exp. = exponential

TABLE 4: GUIDELINE NON-UNAMAP MODELS

TABLE 4. MODEL OPERATION CHARACTERISTICS

Guideline Non-UNAMAP Models
(continued)

Model Acronym	Model Type	Pollutant Types	Plume Rise Treatment	Downwash Considered	Chemical Transformation	Physical Removal	Wind Speed Profile Treatment	Urban or Rural?
MTDDIS	Variable trajec. Gaussian puff	Prim.	Briggs	No	Exp. decay	Dep. & wet removal	Linear	Not specific
MULTIMAX	G.P.	Prim.	Briggs	No	No	No	Exp.	Either
PLMSTAR	Lagrangian photo chemical	O_3, NO_x, SO_x, CO & reactive hydrocarbons	Briggs	No	Atkinson (1982) photochemical mechanism	Dry dep.	Measured & gridded	Either
PLUME 5	G.P.	Prim.	Briggs	No	Exp. decay or O_3 limiting	Exp. decay	Extrapolated or calculated	Either
PPSP	G.P.	Prim.	Briggs	No	No	No	Exp.	Either
RADM	Random Walk Lagrangian dispersion	Inert or exp. decay	Briggs	No	Exp. decay or formation	Dry dep.	Based on roughness & stability	Either

Legend

Appendix A & B = Appendix A or B of EPA Guidelines on Air Quality Models (1986)
B&B = Bjorklund and Bowers (1982)
Briggs = Briggs (1969, 1971, 1975) plume rise equations
CBM-II = Carbon-Bond II Mechanism
dep. = depositon

G.P. = Gaussian Plume
exp decay = exponential decay
Prim. = Primary
non-react. = non-reactive
exp. = exponential

TABLE 4, CONTINUED: GUIDELINE NON-UNAMAP MODELS

TABLE 4. MODEL OPERATION CHARACTERISTICS

Guideline Non-UNAMAP Models
(continued)

Model Acronym	Model Type	Pollutant Types	Plume Rise Treatment	Downwash Considered	Chemical Transformation	Physical Removal	Wind Speed Profile Treatment	Urban or Rural?
RPM-II	Reactive plume	O_3, NO_x, SO_x and reactive hydrocarbons	Briggs	No	CBM-II	No	No	either
RTM-II	Eulerian grid & Lagrangian puff	SO_2 and sulfate	Briggs	No	Linear SO_2 oxidation	Dry and wet deposition	Observed winds	Either
SCSTER	G.P.	Prim.	Briggs	No	Exp. decay	Exp. decay	Exp.	Rural
TCM-2	G.P.	Prim.	Briggs	No	Exp. decay	Exp. decay	Exp.	Urban
TEM-8	G.P.	Non-react.	Briggs	Stack	Exp. decay	Exp. decay	Exp.	Either
Models 3141 & 4141	G.P.	Non-react.	Briggs	No	No	No	Exp.	Either
Visibility Model								
ERT Visibility	G.P.	TSP, NO_2,	Briggs sulfate, nitrate	No	First order	Dry dep.	No	Rural

Legend

Appendix A & B = Appendix A or B of EPA Guidelines on Air Quality Models (1986)
B&B = Bjorklund and Bowers (1982)
Briggs = Briggs (1969, 1971, 1975) plume rise equations
CBM-II = Carbon-Bond II Mechanism
dep. = depositon

G.P. = Gaussian Plume
exp decay = exponential decay
Prim. = Primary
non-react. = non-reactive
exp. = exponential

TABLE 4, CONTINUED: GUIDELINE NON-UNAMAP MODELS

Perhaps the most remarkable property shown in the tables is that almost all of the dispersion models in UNAMAP use Gaussian diffusion where the concentration of a pollutant in the cross-section of a plume resembles the normal (bell) curve.

A glance through Table 4, however, shows that some non-UNAMAP models use different diffusion technologies. The IMPACT model simulates dispersion by using finite-difference methodology to solve a conservation of species equation. The RADM model incorporates a random-walk dispersion. The Guideline model which departs most radically from the Gaussian method is the Urban Airshed Model (UAM). UAM is an urban-scale, three-dimensional model for computing ozone concentrations during one or two day episodes. The model employs numerical methods over a three-dimensional grid.

However, as shown in the tables, the UNAMAP Version 6 models have incorporated advances in other facets of air quality modeling technology. Some Version 6 models handle any number and mix of point, area, and line sources of pollution. Some models incorporate methods to deal with hills or valleys. Some of the more sophisticated models are designed to simulate physical removal or chemical transformation of pollutants as well as dispersion.

2.2.2 Software

The Version 6 models are all written in ANSI Fortran 77 as implemented on the Sperry 1100 Series. There are approximately 90,000 lines of code in all, with individual models containing between 388 and 13,827 lines. Although the accuracy and mathematical soundness of the algorithms has been verified through extensive testing, there is no programming or documentation standard for the models. Many have been modified several times. All models do include sample input and output data sets for testing. The cost of running the Version 6 models against their sample data on the EPA UNIVAC ranges from $.58 to $263.32. All but 8 of the models run for less than $5.00. These dollar amounts reflect the 1986 charge algorithms.

2.3 Data Technology in Version 6

2.3.1 Meteorological Data

Most Version 6 models use meteorological data provided by the National Weather Service (NWS). Surface data are collected hourly while mixing height data are produced twice daily. These data are collected at each of the approximately 300 primary weather stations located at airports plus several hundred other sites designated as secondary, military or cooperative weather stations. Data have been gathered at sites for various periods of time beginning in the late 1940s.

The data are compiled and made available in computerized form through the National Climatic Data Center (NCDC), as illustrated in Figure 1 on the following page. Data are usually aggregated annually, i.e., 8760 hourly readings per year. Several Version 6 models can also use NCDC's STAR (Stability Rose) program which provides a joint frequency distribution of the occurrence of different categories of wind speed, wind direction, and atmospheric stability.

The technology exists to collect meteorological data at the site under study. For several reasons, onsite data are not widely used. First is the expense of collecting the data, and, since onsite data are rarely reused, costs are not reduced by providing the data to others. Also, time becomes a factor because one year must be spent to collect one year's worth of data. Another problem with onsite data is instrument reliability which results in too many missing observations.

However, some of the Version 6 models require onsite data to portray the most accurate conditions. MPDA is a data processor available in Version 6 which accepts both NWS and onsite data. Currently, the output of MPDA may only be used with the TUPOS model. Future versions of MPDA will provide output usable by other UNAMAP models.

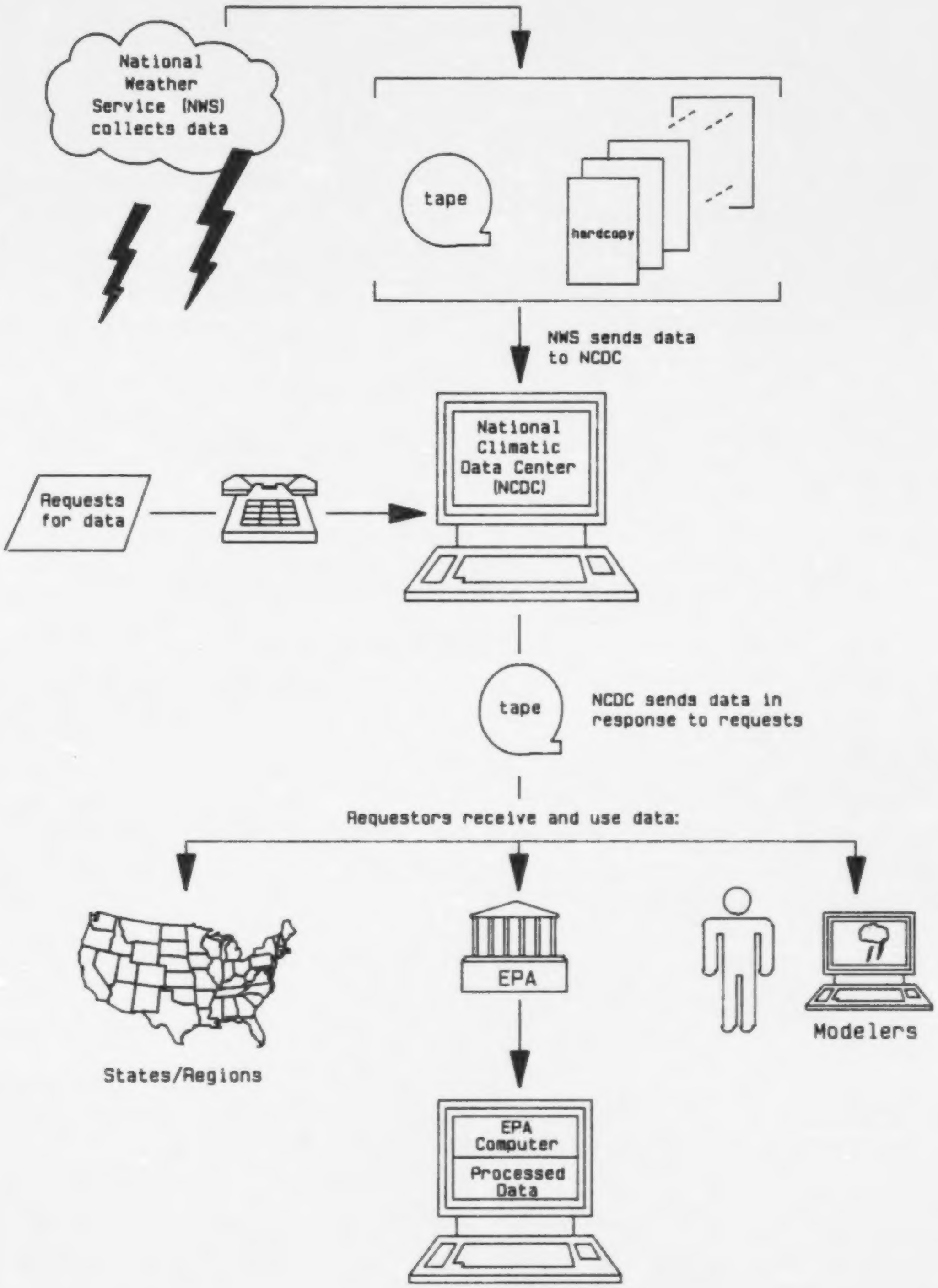
National Weather Service (NWS) collects data
tape
hardcopy
NWS sends data to NCDC
National Climatic Data Center (NCDC)
Requests for data
tape
NCDC sends data in response to requests
Requestors receive and use data:
States/Regions
EPA
Modelers
EPA Computer
Processed Data

FIGURE 1: METEOROLOGICAL DATA TRANSFER PROCESS

The NWS data could be greatly improved from an air quality modeling perspective. Models cannot handle periods where data are missing - the period of record must be complete. Users report that data from some NWS sources can have missing values which limit its usefulness. Also, the raw data from NWS are not immediately usable in the models but must be processed before use.

NWS data need to be processed in various ways. One type of processing is needed to produce certain input variables needed for modeling that are not directly measured. For example, the data contain no direct measure of atmospheric stability which is an important characteristic for dispersion models. Also, the data are collected at only one altitude (the standard is ten meters above the ground) which does not allow consideration of variations in conditions at different heights. Winds at other heights must be estimated by extrapolation techniques. In comparison, onsite data collection can be designed to meet the specific data requirements for the application.

The second type of processing is required due to a change in NCDC data format. NCDC data was previously digitized in a card image format where one line contained one hour of data. The new format, called compact format, has the data organized by data element. NCDC will provide the user with a tape containing all the data or they will process it to pull out selected data elements.

NWS data for a specific time period present another problem to modelers. Until 1964, observations were made each hour by NWS, and the data were entered for each interval. From 1964 until the middle of 1981, although observations were still made each hour, only every third hour was digitized for most stations. In 1981, the digitized interval returned to one hour. Users needing data in this time period must pay an additional amount to get the other two hours digitized by NWS.

2.3.2 Source and Emissions Data

Two kinds of data about the potential generation of pollutants in the area under study are required for most of the models in Version 6: an emissions inventory and the emissions from the actual source. An emission inventory of all sources in the area is often necessary to establish background concentrations. These data are typically gathered by a voluntary, unverified response to a questionnaire administered by the state pollution monitoring agency. Although the data are usually available in automated form, they tend to be incomplete, obsolete, and not in a standardized format from one state to another.

There are three types of emission sources: point, area, and line. To provide the emissions data needed to model a point source, the expected volume of pollutants to be emitted by the pollution source under consideration must be calculated. Emission data will include the emission rate in mass per unit time and information about the source (e.g., stack height, stack diameter, exit velocity, and stack temperature for a point source). The mass per unit of time is generally calculated for the peak capacity of the pollution generating facility. The emissions data can be derived from source testing, engineering mass balance calculations, or generic emission factors applied to process information. If the modeling is being done for a proposed source, the emissions are based upon engineering design information.

For an area source, it would be difficult to obtain the emissions from each piece of the source individually. However, the collective impact of the area is important. For example, a coal pile is a true area source with the particulates arising from the entire pile constituting the emissions. Emissions from fuel combustion by residences, commercial establishments, small industries, motor vehicles, railroads, and aircraft constitute the majority of area source emissions although dust may also be a factor in some cases. Several types of data are used to calculate the emissions for these sources such as fuel sales, number of aircraft arrivals and departures, records of construction sites, and agricultural activities. These data can be obtained from various federal, state, and county records.

Line sources are linear strips such as highways, streets, and airport runways. For highways and streets, the emission calculations require data on the vehicle miles traveled, the width of the street or highway, the number of lanes, and the distribution of traffic among vehicle types. For airports, data is needed on the number of airplane arrivals and departures, the distribution of traffic among different types of aircraft, and the number of engines for each aircraft type. The information is used with the appropriate emission factors to calculate emission rates for unit length of the highway or runway.

2.4 Computer Technology in Version 6

2.4.1 Processing

The resident computer for all UNAMAP Version 6 models is EPA's UNIVAC which resides at the National Computer Center (NCC) in Research Triangle Park, North Carolina. The Sperry 1100 series architecture is approximately 20 years old, and the first EPA UNIVAC machine was purchased in the early 1970s. The operating system is OS 1100, Version 39 R3. There are two CPUs with 14Mb of main memory, and 10 gigabytes of online disk storage. There are 106 synchronous communications ports which can be configured as dial-up or dedicated and 96 asynchronous dial-up lines. The TYMNET communications network is available.

To facilitate scientific computing of the type required for UNAMAP, the UNIVAC has Release 11 of the ANSI FORTRAN compiler which was installed approximately seven years ago. Floating point (decimal) calculations are handled by machine language instructions which perform one floating point double precision add in 120 nanoseconds.

NCC charges only $1050 for an hour of CPU time. While this rate sounds high, it compares quite favorably with some other government charges where a lower CPU rate is offset by a memory charge rate.

2.4.2 Data and File Transfer

Data communications technology is not used to transfer the modeling software or the meteorological data. The National Technical Information Center (NTIS) makes the UNAMAP software available to potential purchasers. NTIS staff members copy the programs onto 9-track magnetic tape, take incoming orders, ship the tapes, and announce the new versions of UNAMAP. Users purchase the magnetic tape which contains all UNAMAP models. There is no provision for buying only some of the models. A prospective UNAMAP purchaser can get the NTIS order number or other information by using the online NTIS database which is available on BRS, DIALOG, Mead, and SDC. There is no electronic distribution and announcement procedure used by NTIS for UNAMAP.

Nationwide meteorological data are made available by NCDC to UNAMAP users on standard 9-track computer tapes in a variety of formats. A fixed length format, card image format and variable length element format are available in ASCII and EBCDIC. For most sites, the entire period of record will fit on one tape. Frequency distributions in paper copy are available.

The cost for NCDC data are dependent on the input/output requirements needed to make the tape. For one year of data requiring one input tape and one output tape, the cost is approximately $100.00. However, the average cost of an order from NCDC ranges from $200 to $500. A written request is not required, although the order must be pre-paid by check or credit card and data are generally received within one to two months after the request is mailed. Requests for current data may take longer.

The EPA UNIVAC at the National Computer Center (NCC) maintains a large amount of meteorological data online which have been processed by the Office of Air Quality Planning and Standards (OAQPS). Regional offices can order data from NCDC, and ask OAQPS to process it. The processed data are then readily accessible to all modelers who use the NCC UNIVAC.

2.4.3 Graphics

Very little graphics technology is utilized in UNAMAP Version 6. Some of the models can produce a data file which is used to plot lines showing coordinates of equal concentrations. These lines, called isopleths, are only produced in dot-matrix or character form; they are not plotted in a continuous line. There are no scale adjustments or variable information which can be added or deleted from the graph. No terminal display of graphics is supported in EPA's Version 6.

2.5 Summary: Technology Utilized by UNAMAP Version 6

In Version 6, the technology applied to modeling has progressed, while that of the computer systems used to run the models has not. Although largely based on the original Gaussian dispersion mathematics, the UNAMAP models have advanced by becoming more sophisticated and consistent and by increasing their usability through adaptation and new processors. On the other hand, the UNIVAC 1100 computer technology utilized to support UNAMAP represents no advances since UNAMAP was begun in 1973.

3.0 DEVELOPMENTS AND ADAPTATIONS OF UNAMAP MODELS TO CURRENT TECHNOLOGY

The field of air quality modeling is still quite dynamic. New, sophisticated models have been developed to model more specialized or more complex problems. Existing models have been adapted to a variety of computers. Many ease of use features have been added to them. The adaptations and processors have been written by users, consultants, and third-party marketers. Together, these new models and features of existing models are important indicators of the technological direction of UNAMAP.

This section will describe the technologies used by models currently under development and adaptations being made to UNAMAP models.

3.1 Modeling Technology

3.1.1 Air Pollution Meteorology

New models are being created both within and outside EPA. One example of EPA design is the Complex Terrain Model Development project which is scheduled for completion in 1987. It is expected that information from this study will help to remedy UNAMAP's lack of an adequate, refined Guideline model for complex terrain. Two UNAMAP models, VALLEY and COMPLEX I, are commonly used for screening purposes in complex terrain. Most states recommend VALLEY over COMPLEX I because COMPLEX I requires onsite meteorological data. Moreover, VALLEY gives conservative predictions which helps to protect air quality. Modeling efforts outside EPA include New York's development of a subroutine for ISCST used to predict pollutant concentrations at receptors that lie above the top of the shortest stack being modeled.

Gaussian models are not applicable to variable conditions such as short-period wind fluctuations and emergency response situations. One new type of model, the "puff" type, overcomes some of these limitations. It concentrates on the trajectory taken by the emissions and predicts the pollutant concentration which occurs within an isolated portion --a puff-- of the plume as it is transported and diffused. The INPUFF model, which is part of UNAMAP, is an example of this type of model.

To fill another need, the Urban Airshed Model has incorporated an atmospheric chemical transformation subroutine which allows the modeler to choose a chemical kinetic mechanism to depict the photochemistry of hydrocarbon-nitrogen oxide-ozone interactions.

3.1.2 Software

Since the UNAMAP source code is readily available to the modeling community, modelers are free to adapt them for problems specific to a locality. Modifications include the addition of new or revised algorithms for calculating plume rise, stack downwash, and pollutant decay rate. Some modeling groups have made extensive modifications to the models to adapt them to their specific requirements.

Pre- and post-processors also adapt the models to the needs of a state or an industry as well as promote ease of use. Post-processors aid in calculation of human exposure values for industries where risk assessment is necessary. Many pre-processors are used to prepare data to meet the varying requirements of the models.

Data output by the models can be cumbersome and voluminous. Many post-processors are used to summarize model results, reformat the output to highlight important points, and to facilitate analysis of the results. They are also used to produce graphic output for presentation to non-modelers.

Processors to ease the task of data input have been developed by individuals; the best known user interfaces are those provided by such third-party marketers as Trinity Consultants and Bowman Environmental Engineering. Their interfaces prompt the user for the necessary data. The user does not have to know the various data input formats required by the different models.

3.2 Data Technology

Evolution of software is not the only area of progress in modeling. Pre-processed and site-specific data improve modeling accuracy by increasing the quality and representativeness of the data used as input to the models.

3.2.1 Meteorological Data

Users may avoid processing raw NWS meteorological data by purchasing pre-processed data. NCDC will pull selected data elements from the compact format, but processing by NCDC is expensive. Some consultants, such as Trinity and Bowman, will process the data into the required format for modeling and provide it to the user on diskettes. The Office of Air Quality Planning and Standards (OAQPS) will provide some data on 9-track tape at the request of the Regional Offices. Some states (e.g., Ohio, New Jersey, and Wisconsin) make the pre-processed data available on floppy diskettes at a nominal charge. A year of processed data can fit on one diskette.

In some areas, airport data are not representative of the site. Despite the drawbacks of cost and difficulty of input, onsite data are used when either the state or the industry decides that site-specific data are necessary for a true picture of meteorological conditions. Some major sources have their own meteorological stations, but the costs for set up and maintenance are too high for most sites. However, the technology needed for data collection is becoming cheaper as microcomputer costs drop, and such stations may be more widely used.

Onsite data are not as easily used with most UNAMAP models as are NWS data, but the improvement in representativeness is frequently worth the cost. When the MPDA pre-processor produces output usable by models other than TUPOS, it will be easier to input onsite data into the UNAMAP models.

Site-specific data are not frequently reused due to the lack of a mechanism which would make the data accessible and promote their use. The potential for re-use of onsite data is limited by the requirement for climatological similarity. The decision on site similarity is based on professional analysis of basic topographical conditions such as size, type, and orientation of geographical features. No quantitative method is available to make this decision.

3.2.2 Source and Emissions Data

Emissions data are now more complete since states are continually improving their emissions inventories. The National Emissions database is available at Research Triangle Park, and is updated quarterly by the states. However, there are some problems with the accuracy of the emissions data. There are errors in such data as estimated emissions and stack heights, and there is little consistency across the country in how to report fugitive emissions rates.

3.3 Computer Technology

3.3.1 Processing

The UNAMAP models have been converted to run on a variety of computers. The conversions have been mainly done, however, by modeling groups using a variety of FORTRAN compilers. It is not difficult to convert the models to run on Digital Equipment VAX computers because of the similarities between the VAX and the UNIVAC FORTRAN compilers. It is also easy to convert the models for the IBM microcomputer. Conversion to the IBM mainframe is the most difficult, while there is an intermediate level of difficulty with the Burroughs.

Some states and regions make their converted version of the models available to groups within their area, and there are two conversions of the UNAMAP models which are commercially available. HMM, in Waltham, MA, sells an IBM mainframe version. Trinity Consultants, Bowman Environmental Engineering, and Clary Associates sell IBM microcomputer versions of the models. The microcomputer versions also use a variety of FORTRAN compilers such as Microsoft and Ryan-McFarland.

3.3.2 Data and File Transfer

Currently, communications technology is mainly used to access either the EPA NCC computer or Regional Office computers. There is very little electronic transfer of data or model code.

3.3.3 Graphics

Graphics technology, however, is widely used. Graphics are particularly important in communicating the results of the model to non-modelers. Both microcomputer and mainframe users of UNAMAP produce graphic output. For mainframe users, post-processors are used to provide the model output in a file for use with graphics software packages.

The microcomputer versions of the models have graphics as part of the package. The most common graphics output is production of isopleths which are connected points of equal concentrations scaled to a USGS 7.5 minute topographic map. Isopleths in different scales and 3-dimensional representation of concentrations are available. Both dot-matrix printers and graphics plotters are used for output, but color displays are less common.

3.4 Summary: Developments and Adaptations of Air Quality Models to Current Technology

Innovations by UNAMAP users have resulted in adaptations to the modeling software, more sophisticated data collection methods, and the increased use of new computer technology. This activity reflects the changes in the typical modeling situation since the UNAMAP models were developed. Modelers have responded to situations that are different or more complex than those for which the software was designed.

Also, the typical model user has changed since the advent of UNAMAP. A user is not necessarily a "modeling expert". Some people use the models only a few times a year and have to relearn them each time. Others, while expert in the meteorological aspects of the models, do not have the computer expertise necessary to use the mainframe versions easily. Individual modelers, state agencies, and third-party marketers are helping to meet today's modeling needs.

4.0 TECHNOLOGY TO SOLVE CURRENT PROBLEMS

The adaptations and new developments discussed in the previous section have arisen out of the user community's need to deal with operational problems encountered in typical air quality modeling applications. Model developers are now starting to turn their attention to more challenging environmental problems. This section will project a picture of the technological milieu in which today's and tomorrow's models will function.

4.1 Modeling Technology

4.1.1 Air Pollution Meteorology

Since its beginning in the late 1960s, air quality modeling has been a useful and important tool in protecting the environment. Because of the acceptance of air quality modeling, models are now being asked to meet the needs of even more complex, real-world situations which need representation.

Regional models are needed by county, regional, and state agencies to study dispersion and transport of pollutants over larger distances. Regional models must handle data from several areas along the path of the plume. Multiple wind speeds, wind directions, and atmospheric stability situations must be represented. Trajectories are plotted to discover the destination of the pollutant and its concentration.

Because of the complexity of the situations being modeled, regional models will be larger and more complex. Although interest in acid precipitation will increase the application of regional models, these models will not have as many users as those for geographically localized sources. Their use will be limited by the smaller number of situations needing such a model, the model's large size, and the increased difficulty of use. To meet user requirements within EPA for the execution of these models, the Meteorology Division is establishing a program for advanced model operation and analysis. The program will provide the models, computer resources, and the personnel to run them.

Complex terrain models will more realistically represent geographical areas where terrain is a factor. These models will need to solve problems such as valley stagnation, where the wind speed is zero, and treatment of the leeside of terrain obstacles. The early UNAMAP models would not handle an obstacle higher than the lowest stack. Later models, such as COMPLEX and VALLEY, allowed the plume to rise over the obstruction.

Modeling has great potential for use in such areas as toxic gases, radiological pollutants, emergency release situations, and offshore sites. For toxic gases, models are being used to predict the dispersion of fugitive emissions as well as emissions from known point sources. Some toxic gases, however, are heavier than air, and current Guideline models cannot be used for them.

Modeling of instantaneous releases of gaseous pollutants has increased. The releases may be from a spill or other accidental occurrence where the emission is not continuous. These models may include the release rate plus vaporization activity so the model depicts physical changes as well as dispersion.

Offshore sites and those on shorelines have special dispersion characteristics due to the differences in stability over land and water. More realistic models are being developed to represent dispersion of emissions from offshore sites.

4.1.2 Software

The modeling software needed to handle current and future modeling situations must meet certain requirements. The continued use of a standard language such as ANSI FORTRAN 77 is necessary for conversion to the various hardware systems available now and in the future.

Changes in programming methods can affect other modeling needs. Structured programming techniques will promote better internal program documentation and allow easier modification of the models. Run-time efficiency is being improved to facilitate the use of larger models and microcomputer processing.

Changes will also be seen within the modeling software itself. The software will include more intricate equations to adequately represent the complex situations being modeled. New functions such as statistics and health-risk assessment factors will be added.

Consistency of input and output among the models will need to be increased as the number of non-expert modelers increases. Standard data input formats will ease the data-entry bottleneck which currently exists. The format of the model output will become more standardized, and the models will produce reports which are easily interpreted and quickly generated.

4.2 Data Technology

4.2.1 Meteorological Data

The data technology must improve to meet the demands of air quality modeling in the future. This improvement will result in better data for current models and will meet the data requirements of new models. Improvements in the quality and quantity of both onsite and NWS data collected for current models will increase the accuracy of the models' predictions. The current trend of collecting more onsite data will continue, and the technology for the collection and processing of this data will improve.

NWS data will continue to be important in modeling. The data collected, however, will change. Improvement will come through the use of automated data gathering instrumentation. More data will be collected per site, and at more sites, than is possible with present NWS staffing. Modeling requires better representation of wind conditions, such as an hourly wind value which is an average of the winds during the hour instead of a single reading. Hourly measurement of the mixing height, as is possible with new monitoring equipment, would be a considerable improvement over interpolations from measurements taken every 12 hours. Measurement of the standard deviation of horizontal wind direction fluctuations can be used directly to calculate horizontal dispersion.

NWS has various plans for continuing to improve their data. The plans include updating the following activities: observation procedures, reporting processes, and archiving functions.

4.2.2 Source and Emissions Data

Emissions data will also need improvement to increase model accuracy. Emissions inventories will expand to include more substances, and the accuracy of reported data must increase.

4.3 Computer Technology

4.3.1 Processing

Processing for air quality modeling will continue on the current path toward more distributed processing. Most of the day-to-day modeling activities will be done on microcomputers while the large regional and complex terrain models will be run on mainframes and supercomputers. Other modeling activities such as software development and time-sharing will be done on more user-friendly, scientific machines such as the VAX.

Microcomputers have already begun to replace mainframes for running the standard models. Improvements in microcomputer technology are producing faster equipment with increased disk storage at affordable prices. The technology is available to process the most common modeling runs on microcomputers using little more total elapsed time than that needed to submit the job and receive the results via telecommunications facilities to a large system. Some of the Version 6 models are available on microcomputers, and others will be converted.

Mainframe computers will continue to be a necessary processing environment for some types of modeling situations. While IBM mainframe computers are not the specialized, scientific machine best-suited to modeling activities, their general popularity makes them an attractive target for larger models such as the regional models.

4.3.2 Data and File Transfer

The activities necessary to acquire data require no modeling expertise but can require a great deal of time. Future utilization of electronic communications will allow modelers to share data and modeling software more easily. Electronic bulletin board software allows multiple users to dial in to a system which will provide news, "mailbox" communications with other users, and the ability to download data from the system. If such a system were operated by EPA, users would be able to look at a list of data files available from OAQPS and from other users.

Data transfer could be facilitated in two ways. For data only available from other users, the owner plus a description of the data would be listed, and the requestor would contact the owner directly or through the electronic mail facility. After any payment or other issues were worked out between them, the owner could upload the data onto the system for downloading or data diskettes could be mailed. For onsite data, the costs for collection are high, both in time and money. Sharing this data would allow some cost recovery for onsite collection as well as provide others access to more representative data in a timely manner. The data would remain the property of the collector, but it could be shared with others willing to pay a price set by the owner. Onsite data has been used by modelers other than the collectors of the data, but there is no method currently in place to streamline the process. The most cost-effective method would be for EPA to provide a mechanism by which the modeling community could share information on what data are available. Permitting agencies may have a need to access onsite data files used in the permitting process in order to verify their accuracy. The bulletin board, however, is not seen as the best mechanism for providing that type of access.

Certain NCDC or OAQPS data could be available for downloading by users through the bulletin board. One or more telephone lines into the bulletin board could be reserved for downloading so that other, less time-consuming, functions would not be adversely affected. Electronic transfer of NWS data would ease several data problems. The first problem is the time modelers spend waiting for the arrival of data. By downloading data through the bulletin board, the data would be available within a few hours or less depending on the amount of data transferred. Even if data diskettes were sent through the mail, the time spent waiting would be less because the request process would take less time.

Second, sharing of data by users (both NCDC and onsite data) would be easier. Shared NCDC data would lower the demand on NCDC staff.

A third problem addressed by electronic data transfer is the time and knowledge required to use a preprocessor on a data file. Sharing of preprocessed NWS and onsite data would make running the models quicker and easier, especially for the novice or infrequent users.

In addition to electronic transfer of data, file transfer will also address problems confronted by modelers. Infrequently used or new models could be shared allowing all areas to serve their end-users most economically. File transfer could provide corrections to models and documentation in a manner which is more timely and economical than is currently available. The bulletin board could also allow users to share modifications they have made to the models or processors. Such sharing would encourage consistency and allow all users to enjoy the benefits provided by the modifications.

5.0 SUMMARY

All products follow a pattern of growth, the life cycle of the product, which involves changes to the product, the users, and the market. UNAMAP has followed the evolutionary stages common to such a cycle. The first stage, typical of a new product, is a testing period where changes are made to bring the program into line with the original specifications.

When the UNAMAP program began in 1973, the field of air quality simulation modeling was still new. The testing period was made easier because the models were a great improvement over previous methods, the modeling community was small, and modeling needs were well-defined. The computer technology chosen was the best available product which met the needs of the time. At this stage, most users were "experts" in the product because there were few support services available. During this period, the UNAMAP users and developers (often the same people) worked together to improve the program.

In the product life cycle, the testing period is followed by one of adaptation. During this period, memory of life without the product fades, and new requirements emerge to be met with a wave of modifications. UNAMAP is currently in this phase of the cycle.

As the field of modeling and the UNAMAP product matured, modeling began to be applied to new situations. People are working around problems in UNAMAP by developing processors and adapting the models to specific conditions. The user community has shifted toward the non-expert user who is not willing or lacks the skills necessary to provide his own support. A peripheral market of services and products has grown around UNAMAP with consultants to advise or perform the modeling activities, software conversions to other hardware, and proprietary models.

By Version 6, the models had increased in sophistication and consistency while processors and adaptations improved the usability of the software. However, the computer technology for which UNAMAP models are designed is no longer the most appropriate. Many users want the models to run on their own microcomputers or on local or regional hardware. Early in the period of adaptation, it is difficult for the developers to identify the needs which will be important to the community as a whole. Users, therefore, institute the changes themselves or find an outside party to do it for them.

The third stage of the cycle is the emergence of a mature product usable by those with a variety of skill levels and with an increased flexibility and range of application. The objective of this project is to provide the information necessary for UNAMAP to move into the third stage. The modeling software must continue to change to meet current needs, and the range of applications must increase. Although some regional and complex terrain models currently exist, refined, fully-developed models are required. Models for toxic materials, emergency release situations, and offshore sites must be included.

The UNAMAP user will continue to be non-expert. The proliferation of user-friendly, microcomputer products will lead to increased expectations which the UNAMAP software must meet. There must, also, be more consistency of data input and output among the models to facilitate the novice or infrequent user.

Computer technology will continue its trend toward distributed processing with microcomputers used for an increasing amount of modeling activity including more graphics. User expectations will also require that data gathering and file transfer technologies in UNAMAP match those available in other areas.

The UNAMAP models have been and will continue to be important tools for protecting air quality. The final report of this project will provide the information necessary to make them responsive to the needs of the user community.

EVALUATION AND ASSESSMENT OF UNAMAP

PART III: INTERIM REPORT

November 1987

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EVALUATION AND ASSESSMENT OF UNAMAP
PART III: INTERIM REPORT

1.0 INTRODUCTION

1.1 Background

The User's Network for Applied Modeling of Air Pollution (UNAMAP) models are provided by the Environmental Protection Agency (EPA). This software library is made up of the models whose development was funded by EPA or whose use is recommended for environmental impact analysis by EPA's Office of Air Quality Planning and Standards (OAQPS). The Environmental Operations Branch (EOB) is part of the Meteorology Division within EPA's Office of Research and Development (ORD). EOB staff have two major areas of responsibility: 1) continuing research in dispersion modeling; 2) technology transfer of air quality dispersion modeling to the public. Distribution and support for UNAMAP are funded by EOB as part of their technology transfer function.

As part of its ongoing effort to improve the utility and availability of UNAMAP to the public, EOB commissioned the evaluation study of which this report is a part. A major portion of the study was to collect data from UNAMAP users and other segments of the dispersion modeling community. The data collection was to serve two objectives. One objective was to determine who the UNAMAP users were and how models were used. The second was to find those areas where the modeling community felt that improvement was required. The purposes of this report are: (1) to present the data collected from the users, (2) to describe areas where improvement of UNAMAP would be most beneficial, and (3) to make a set of recommendations for those improvements.

1.2 Data Collection and Analysis

Data was collected in two phases. The first phase was a set of 22 in-depth interviews with key members of the UNAMAP community as identified by Battelle and EOB. Interviews were conducted with representatives of the following organizations:

EPA (including ORD & OAQPS)	6
State agencies	6
Regional Meteorologists	2
Consultants	2
Private industry	2
Local or county agencies	1
Software marketers	2
Educational institutions	1
TOTAL	22

The interviews yielded great insight into the complexity of UNAMAP and the nuances of modeling. They also formed the basis for the construction of a questionnaire to be mailed to a larger segment of the UNAMAP community.

The questionnaire was mailed to 275 organizations selected from the directory of the Air Pollution Control Association and from the list of UNAMAP purchasers. The questionnaire includes the following sections:

- User profile
- Models used
- Training, documentation, and support experience
- Hardware available
- Problem areas
- Suggestions for improvement

Responses were submitted by 106 organizations. A copy of the survey guide is in Appendix A; the questionnaire is in Appendix B.

The remainder of Section 1 presents a summary of the findings including a user profile, discussion of how the problem area data was analyzed, and an overview of the most frequently mentioned problem areas. Sections 2 through 7 discuss in detail each major area of improvement, and Section 8 summarizes other user concerns. A description of overall constraints or factors limiting improvement is given in Section 9, and Battelle's recommendations are presented in Section 10. Section 11 describes why certain alternatives or suggestions were not recommended, and Section 12 is a brief summary.

1.3 UNAMAP User Profile

Response from a cross-section of the modeling community was necessary to evaluate needs and make recommendations applicable to all. The first section of the questionnaire elicited a profile of the UNAMAP users. Users were asked about their industry affiliation, their years of modeling experience, and the nature of their work with air quality simulation models (AQSM).

Respondents to the questionnaire are members of distinct segments of the industry. Consultants and state government agencies returned the largest number of questionnaires (35 each), followed by private industry (23), local government users (9), and other users (4). Table 1 shows the questionnaire respondents by industry group. Due to the structure of the sample group, it is not possible to say that consultants and state users actually represent the majority of the total UNAMAP users.

The experience levels varied by industry groups. Consultants had the highest average with more than 10 years experience, and state governments had the most persons with 5 to 10 years experience. Table 2 gives the number of respondents per user group and their years of experience.

Respondents were also asked to categorize the nature of their involvement with the models. Because the majority of questionnaire respondents indicated they were users of the models, the two terms, users and respondents, will be used interchangeably throughout this report. Other categories of involvement are data provider, developer, remarketer, software support, and validator. See Table 3 for more specific statistical data.

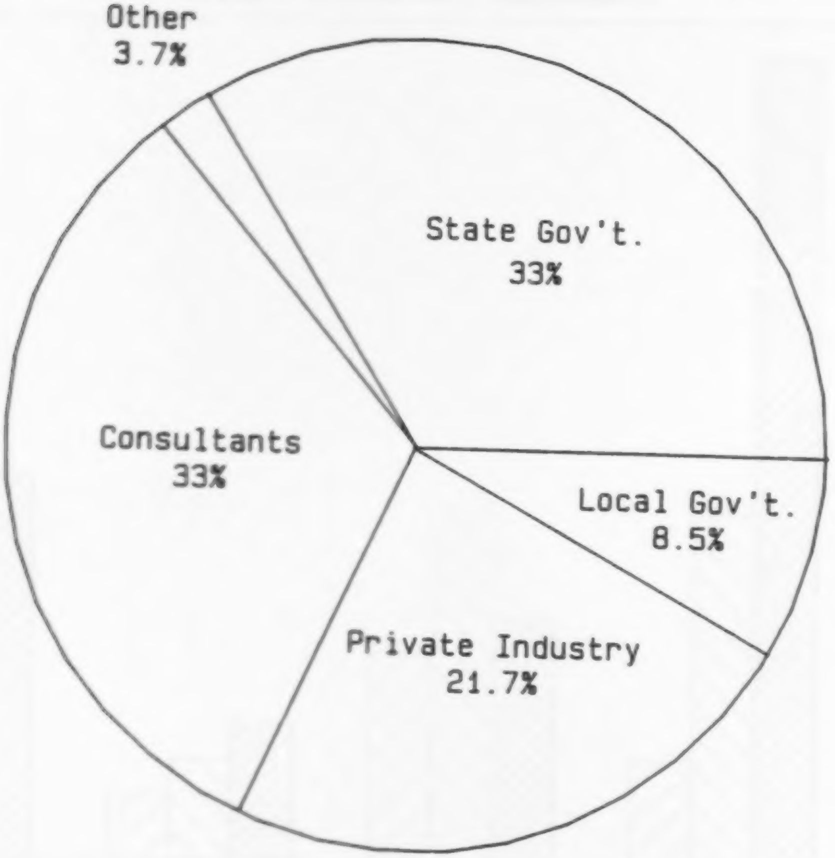

Table 1. Questionnaire Respondents by Industry Group

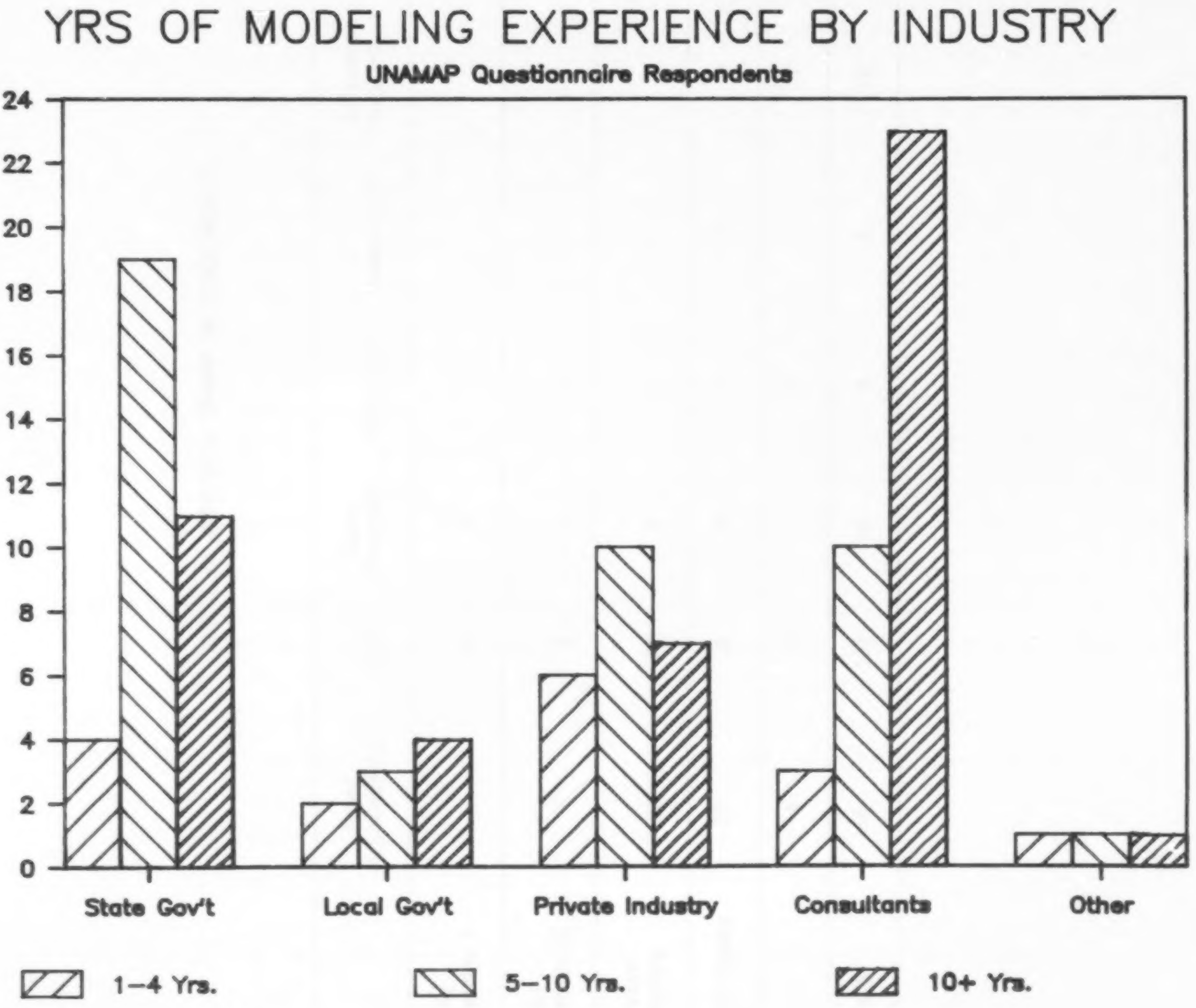

Table 2. Years of Modeling Experience by Industry Group

NATURE OF WORK WITH UNAMAP OR OTHER MODELS

	Total Respondents	User	Data Provider	Developer	Remarketer	Software Support	Validator	Other
State Government	35	34	3	1		1	2	
Local Government	9	9	2	2		2		
Private Industry	23	21	3	1		4	1	
Consultants	35	35	2	3	3	4		
Other	4	2		2		1		
TOTALS	106	101	10	9	3	12	3	0

Table 3. Nature of Respondents' Work with UANMAP

1.4 Analysis of Problems/Suggestions

The largest portion of the questionnaire dealt with the problems perceived by the users and their suggestions for improvement. Twelve problem areas were identified by Battelle project team members based on conversations with EPA. The areas included in the questionnaire and interview guide are:

1) Choosing a model
2) Accuracy of the models
3) Buying/accessing the models
4) Documentation for the models
5) Support for the models
6) Data collection
7) Data input
8) Hardware compatibility
9) Hardware access
10) Unreliable hardware
11) Response time
12) Other

Questionnaire respondents were asked to rank the list of twelve possible problem areas on a scale of 0 to 10 where 0 indicated the area is not a problem and 10 that the area is a severe problem. User responses were grouped with 0 to 2 identified as a low ranking, 3 to 6 a medium, and 7 to 10 a high ranking. Data from the interviews was summarized into the same categories as those of the questionnaire. Unless otherwise indicated, all discussion of user opinions and requirements will represent a combination of questionnaire responses and interview transcriptions.

To qualify for further analysis, a problem area was required to be scored "medium" or "high" on the severity scale by all of the major user categories: state agencies, private industry, consultants, and local agencies. Table 4 gives the complete data.

PROBLEM AREAS (Q.15)

User Group	Total Respondents	Item: 1	2	3	4	5	6	7	8	9	10	11	12
Private Industry	23	L	H	L	M	M	EVEN	EVEN	EVEN	L	L	L	
Consultants	35	L-M	H	L	M	M-H	M	L	M	L	L	L	
Educational Insts.	1	L	M		M		H	H	L	L	L		
Federal Government	3	L	H	M	M	H	L	L	L	L	L	L	
State Government	35	L	H	L	M	M	H	L	EVEN	L	L	L	
Local Government	9	M	M	L-M	M	M	M	EVEN	H	L	L	M	
OVERALL	106*	L	H	L	M	M	M (EVEN)	L	L (EVEN)	L	L	L	

Items:
1. Choosing a model
2. Accuracy of model
3. Buying/accessing the model
4. Documentation for the model
5. Support for the model
6. Data collection
7. Data input
8. Hardware compatibility
9. Hardware access
10. Unreliable hardware
11. Response time
12. Other

Explanation: Respondents were asked to rank each item on a scale from 0 to 10, where 0 meant that the item was 'not a problem', and 10 meant that the item was a 'severe problem.' In the above table, 'L' corresponds to rank values 0 - 2, 'M' to 3 - 6, and 'H' to 7 - 10, indicating the low, medium, or high significance of the item as a problem for the respondents. The 'L' under Item 1 for Private Industry, for example, indicates that more industry respondents gave Item 1 a rank value in the range 0 - 2 than gave it any other rank. 'EVEN' indicates that the responses were evenly distributed among the rank values.

* 118 questionnaires were returned, but 12 were blank, for a total of 106 respondents.

Table 4. Severity of Problems by Industry Group

Each qualified problem was then analyzed by the project team to determine the following:

- Importance to the users
- User suggestions
- Alternatives
- Evaluation criteria
- Constraints

Determination of importance was based on the proportion of questionnaire respondents who felt that there was a problem. Interview transcriptions were examined for further verification. The number of suggestions by users was also a factor.

The suggestions themselves were analyzed by putting them into categories. Percentages were calculated for each category.

Alternatives were generated from interview and questionnaire suggestions and from the experience of the Battelle staff in solving similar problems. Evaluation criteria and constraints were identified from the same sources, and used to determine the strengths and weaknesses of the alternatives.

By evaluating the suggestions and alternatives, Battelle developed a list of recommendations based on the data and previous professional experience. The recommendations were formulated to address multiple problem areas wherever practical, and to utilize technology which is available to the UNAMAP support staff and model users. Estimates are given for the time and cost necessary to implement the recommendations (see Section 10).

1.5 Overview of Problem Areas

As indicated in Table 4, user responses show that the following problems were of greatest concern to questionnaire respondents:

- Accuracy of models
- Documentation of models

- Support for models
- Data collection
- Data input
- Hardware compatibility

Respondents consistently ranked accuracy of the models high on the scale, indicating that it is an area of significant concern among UNAMAP users. Documentation and support for the models are also items of concern for all users. State government users (including one respondent from an educational institution) see data collection as a significant problem. In addition, local government users, as well as others, view hardware compatibility as a major problem.

The concerns about data input and output format were expressed primarily in the interviews. Those interviewed generally indicated data input seemed inordinately complex and time-consuming, given the actual processing that occurs. This is made even more obvious when comparing to the microcomputer versions of models produced by Bowman Engineers and Trinity Consultants. The output of the models was regarded by the users as too voluminous, and the format was seen as not useful. Interviewees suggested that more flexibility in output format would be an improvement in this area. In particular, the ability to suppress the insignificant portions of the concentration matrix was requested.

The following sections will discuss the major problem areas.

2.0 MODEL ACCURACY

While no model represents reality with absolute accuracy, the degree of accuracy and its limits are important to model users. In regulatory usage, UNAMAP model results are the primary basis for decisions such as State Implementation Plan (SIP) revisions, prevention of significant deterioration (PSD) permitting, and permits for proposed sources of air pollution. Users of UNAMAP and management decision-makers must know how to evaluate the accuracy of the model results.

The accuracy of a model is determined by comparing the concentration estimates derived during the modeling process with actual measurements of the air quality. There are two components to model accuracy -- inherent uncertainty and reducible uncertainty. The inherent uncertainty of the models results from variations in unknown conditions such as the exact dispersion characteristics of the pollutants. Reducible uncertainties are caused by uncertainties in emission characteristics, errors in meteorological data, and inadequacies in model physics and formulation.

The most commonly stated accuracy measurement for air quality simulation models is a factor-of-two accuracy. The actual measurements may be as low as the model results divided by two or as high as the results multiplied by two. Actually, however, the accuracy of model estimates vary depending on the model used, the type of application, and site-specific characteristics. Also, many users believe that the models tend to over-predict in order to protect the environment. Users report that models are quite sensitive to minor deviations. For example, the choice of one switch over another or changing one number in wind direction can drastically change the accuracy of the results for the specified actual meteorology and emissions.

2.1 Importance of Accuracy

A majority of users consider model accuracy a problem. Several users expressed serious concern that decision-makers did not know how to interpret information on model accuracy. Accuracy was given a high ranking (7 to 10 on the scale) by 48% of questionnaire respondents. Another 26% gave it a medium ranking (3 to 6 on the scale). For those interviewed, 55% cited it as a problem with one declaring decisions on the accuracy of a model in complex terrain as his biggest problem.

2.2 User Suggestions

A total of 38 suggestions for improving the accuracy of the models were made by UNAMAP users. Most suggestions fell into four major categories:

- Of the suggestions, 50% dealt with model validation and evaluation, including peer review and real-world testing, as well as improving the availability of validation/evaluation results.
- Improvement of the scientific basis of dispersion models and correcting perceived errors in current models were suggested by 30% of the users.
- Eighteen percent of the users suggested the inclusion of a statement of the error bounds or uncertainty with the models, and/or stating the error in terms of confidence intervals.
- Improved data and more models which can handle site-specific data were suggested by 13% of the respondents.

2.3 User Concerns and Alternatives

2.3.1 Concerns

Users identified three types of issues within the area of model accuracy. First, users do not know the accuracy of a model in some specific situations such as complex terrain. Second, there is no easily understood method of communicating the accuracy of a model to users and decision-makers. Third, proving and improving the accuracy of current and future models is needed to increase industry confidence.

To some extent, model accuracy is limited by data precision. The relationship between the factors of data and accuracy should be determined. In this section, we will address non-data related alternatives. Data problems are discussed in Sections 5 and 6.

2.3.2 Alternatives

There are several alternatives available which address one or more of the accuracy issues. The ultimate solution is to develop and utilize a model which is more defensible from a technical standpoint. This alternative would include more model validation and evaluation activities, within specific situations, for a variety of models. A broadening of the peer review process would give more segments of the modeling community a voice in identifying and developing solutions to help identify accuracy problems in the current models. Funding would also be used for research to improve the scientific basis of dispersion modeling.

A second alternative is to establish an improved dissemination process for those evaluations and validations which have been conducted. This could be combined with non-technical discussions of accuracy. For example, general statements regarding model accuracy and comparison of results could be included in the user's manual for each model.

The third alternative is to state the model results in terms of confidence intervals. Techniques to incorporate confidence intervals into the models or into a post-processor would be developed.

2.4 Evaluating Accuracy Alternatives

Improvements to the accuracy of UNAMAP models are not currently cheap or easy to come by. The obvious model improvements have generally been made. The same criteria are important for each of the three concerns -- situation-specific accuracy, easily communicated statements of accuracy, and improvements to accuracy. The first criterion is the cost of the solution. The estimated dollars and staff time to pursue any alternative must be considered. Second is the solution's effectiveness: To what degree will the alternative improve accuracy or improve users understanding of accuracy? Third is the alternative's applicability. The breadth of impact must be evaluated in terms of number of models, segments of the UNAMAP community, and number of specific situations -- currently and in the anticipated future.

2.5 Constraints

A variety of constraints make knowing and improving AQSM accuracy challenging. First, there are not many thorough model evaluations in the literature. Therefore, the amount of information available, especially for specific situations, is quite limited. Second, resources for new model development or improving existing models are quite limited. This fact not only slows research and development, it increases the gap between the best modeling technology and regulatory model technology by limiting the work which is required for regulatory approval.

3.0 DOCUMENTATION

Most UNAMAP Version 6 models (all of them except two) have some type of manual -- most frequently a user's guide. Guideline models have the bibliographic and ordering information for the documentation listed with the description of each model.

Because UNAMAP models have been developed over a long period of time and by many organizations, the documentation for a model is generally written by the developer of the model. Therefore, the type of manuals available as well as their content, format, and quality varies from model to model. Current UNAMAP documentation must serve three types of users: decision-makers, dispersion meteorologists, and data processing personnel. Each of these user categories has distinct information needs. To help improve the quality and consistency of the user's manuals, EPA produced a manual, Handbook for Preparing User's Guides for Air Quality Models (EPA, May 1983).

3.1 Importance of Documentation

Documentation is very important to the users. Many users stated that the manual was their main means of learning how to use the models. Also, the proliferation of user-friendly, microcomputer products for other applications has led to a generally increased level of expectation in terms of documentation clarity and ease of use. The UNAMAP system must meet these expectations. When asked to rank the importance of the documentation to them on a scale of 0 to 10 the responses have a mean value of 8.6 with a standard deviation of 1.45. Users were also asked to rank UNAMAP documentation in terms of ease of use. The mean response was 5.4 on a 0 to 10 scale (where 0 was very difficult and 10 was very easy). The 3 point difference indicates that documentation useability may not be commensurate with its importance. One interviewer said that using the documentation was his biggest problem. Table 5 shows the responses by user categories as well as the total number of responses.

DOCUMENTATION IMPORTANCE VS. EASE OF USE:

Mean and Standard Deviation of Both Questions by Industry Group

	IMPORTANCE OF DOCUMENTATION[1]			EASE OF USE OF DOCUMENTATION[2]		
	N	Mean	Standard Deviation	N	Mean	Standard Deviation
State Government	34	8.4	1.48	33	5.4	1.78
Local Government	9	8.8	1.48	9	5.4	2.30
Private Industry	21	8.6	1.40	21	5.2	2.18
Consultants	35	8.7	1.53	35	5.5	1.29
Other	2	9.0	1.41	2	6.5	0.71
TOTALS	101	8.6	1.45	100	5.4	1.97

[1] Ranked on a scale from 0 to 10, where 0 meant 'not at all' and 10 meant 'totally'.

[2] Ranked on a scale from 0 to 10, where 0 meant 'extremely hard' and 10 meant 'very easy'.

Table 5. Documentation Importance Vs. Ease of Use

3.2 User Suggestions

Most respondents said that, at a minimum, documentation needed some improvement. A total of 72 suggestions were made by users, primarily in the following categories:

- The most common suggestions (over 26%) concerned rewriting, reorganizing, or otherwise making the documentation easier to read and understand.

- Another 18% of the suggestions were that all models needed documentation. Complex I and II were mentioned in nearly every case. Some also suggested documenting the preprocessors such as RAMMET.

- Many suggestions (15%) were to include more examples of model usage especially more variety of input files, area sources, and elevated terrain in the models that deal with those items.

- Receiving updates and corrections as models and documentation are revised was mentioned in 14% of the suggestions.

- More timely preparation and distribution of documentation was the topic of over 12% of the suggestions.

- Writing various parts of the documentation for different users (evaluators, computer analysts, and end-users) was suggested over 8% of the time.

3.3 User Concerns and Alternatives

3.3.1 Concerns

The above suggestions point to the conclusion that UNAMAP model documentation is not oriented to those segments of the community that need it most: the novice or infrequent user. Instead the documentation tends to be directed to the AQSM researcher or evaluator. The novice or infrequent user has difficulty locating the information he needs due to inconsistencies in format and level of detail across models.

Also, the lack of a working, established mechanism for the distribution of changes or updates to the documentation compounds the problem for experienced and novice users alike. Experienced users work from memory of previous versions, thus making errors and not taking advantage of new capabilities. Novice users call for more support.

3.3.2 Alternatives

To meet the needs of UNAMAP users, there is no question that the documentation should be improved in the following areas: media, priorities, and format.

One alternative, which would address the problems of documentation and update distribution, is to provide documentation via electronic media. The distribution and update process would be simplified, improved, and would allow for more timely provision of information.

This solution, however, is not without problems of its own. Decisions would be needed on the precise format of the medium, the distribution mechanism, and how graphics would be handled. Various media formats are available such as word processing diskette, tape, or a file transfer process. Distribution mechanism alternatives include NTIS, EPA Regional Office, EOB, or an electronic bulletin board. Graphics would be the biggest problem since the format is specific to an output device. It is possible that graphics page updates could be provided on paper to give a more uniform look to the manual.

An alternative is needed to attack the ease-of-use issue. Producing a separate set of user manuals for the novice or infrequent user would allow information to be presented with more "cookbook" instructions and more examples.

A different alternative is to update the existing manuals in line with user suggestions. Creating new indexes, clarifying certain sections, and preparing a manual for Complex I are examples of improvements under this alternative.

3.4 Evaluating Documentation Alternatives

Several factors must be weighed before a documentation improvement approach is chosen. First, the feasibility of electronic documentation depends on the existence, cost, and efficiency of an electronic distribution network, and on the availability of hardware for output (especially graphics). Second, any alternative must be evaluated on the method used to incorporate updates and changes. Third, a pilot test of any improvement must be performed by the users.

3.5 Constraints

Preparing documentation is time-consuming and requires personnel with certain skills. EPA currently has limited staff, and the staff that is available does not have the specialized knowledge necessary to organize an extensive documentation project. Another constraint is the existing distribution channels. The formal distribution mechanism of ordering documentation from NTIS is not conducive to frequent updates. While Regional Offices provide informal documentation distribution services, EOB does not have the personnel resources available to assume formal responsibility.

4.0 USER SUPPORT

One of EOB's mandates is to facilitate the technology transfer process in air quality modeling. In this process, the technology provider supplies the expertise necessary for the recipients to apply the technology successfully. For UNAMAP, technology transfer means that support must be provided to model users, and that support must be consistent and accessible.

User support consists of information and assistance provided to answer questions and give guidance as to the proper application and successful execution of the UNAMAP models. Generally, support can be described as either policy guidance or technical support. Policy guidance refers to the specification of models, options, and data necessary to satisfy regulatory requirements. Technical support is largely a troubleshooting exercise as errors occur in such processes as compilation, data preprocessing, or execution. Troubleshooting is also necessary after execution if improbable results are obtained. The distinction between policy guidance and technical support can blur, however, when questions of accuracy or meteorological appropriateness arise. Table 6 indicates the steps in the modeling process where respondents seek support.

4.1 Importance of Support

Overall, support was rated as at least a medium level problem by all user groups. Consultants rated this area as a medium to high level problem.

4.2 User Suggestions

Thirty-four suggestions for improving UNAMAP support were offered in the questionnaires and interviews. In general, more experienced and sophisticated users reported fewer technical problems. Some of these users, however, had the most severe policy guidance problems. Suggestions for improving support tended to fall into the following categories:

SUPPORT REQUESTS BY UNAMAP QUESTIONNAIRE RESPONDENTS:

Type of Support Requested by Industry Group

	Number of Entries*	Choosing a Model to Use	Supplies Data	Software Problems	Interpreting Results	Programming Questions
State Government	34	16	7	12	18	9
Local Government	14	10	3	7	7	8
Private Industry	17	9	5	8	7	6
Consultants	47	15	14	26	10	20
Other	3	0	0	3	2	2
TOTALS	115	50	29	56	44	45

* Greater than number of respondents in an industry group because multiple support organizations used.

Table 6. Type of Support Requested By UNAMAP Users

- The most common suggestion (44%) was to identify and publicize a dedicated UNAMAP support group to deal with all issues.

- Nearly 18% of the suggestions were to establish either a newsletter or a computer bulletin board to distribute modeling information, decisions, updates, and corrections.

- Almost 12% thought support could be improved by converting all models to a specified, common version of Fortran.

- Nine percent suggested that uniformity and standards within the models would solve their support problems.

- Another 9% felt that support could be improved through a clarification of ORD vs. OAQPS roles regarding UNAMAP.

4.3 User Concerns and Alternatives

4.3.1 Concerns

Although the quality of support was generally given a high rating, the real problem was determining the source of the required support. This was reflected in the number of organizations listed by users as providing support to them. For example, within EPA, the Meteorology and Assessment Division helps users with the modeling software, while the Office of Air Quality Policy and Standards (OAQPS) answers questions on regulatory issues. A composite list by user group, shown in Table 7, lists the names of support organizations verbatim from the questionnaires.

In the majority of the suggestions above, users are indicating that UNAMAP support is too fragmented and decentralized. This fragmentation, however, is explainable given the history of UNAMAP. Each of the 24 models is a complex piece of software incorporating sophisticated meteorological mathematics. The models were developed by different sources over a period of nearly 15 years.

LIST OF ORGANIZATIONS USED FOR UNAMAP SUPPORT BY QUESTIONNAIRE RESPONDENTS

	NAME OF ORGANIZATION PROVIDING SUPPORT	# RESPONDENTS
State Government	EPA Regional Office	22
	EPA	3
	EPA/RTP	3
	OAQPS/RTP	2
	U.S. EPA - Atmospheric Science Research Lab	1
	Miss. Dept. of Natural Resources	1
	Radian Corp.	1
	Trinity Consultants	1
Local Government	EPA Regional Office	5
	U.S. EPA	2
	EPA/RTP	1
	EPA Ohio	1
	California Air Resources Board	1
	Lawrence Livermore Laboratories	1
	PEI	1
	Philadelphia AMS	1
	Trinity Consultants	1
Private Industry	Texas Air Control Board	3
	U.S. EPA	3
	EPA Regional	2
	U.S. EPA/OAQPS	1
	EPA - Meteorology & Assessment Div.	1
	NCC	1
	B. Turner	1
	NTIS	1
	Coast Guard	1
	NOAA/NCDC	1
	Oregon State Air Quality Agency	1
	Trinity Consultants	1

Table 7. Names of Organizations Used for UNAMAP Support

	NAME OF ORGANIZATION PROVIDING SUPPORT	# RESPONDENTS
Consultants	EPA	10
	EPA Regional Office	7
	EPA/RTP	6
	U.S. EPA - Environmental Opers. Branch	3
	EPA - Meteorological Lab	1
	EPA - Model Applications Section	1
	EPA - Model Clearinghouse	1
	OAQPS	1
	National Climatic Center	4
	Cramer (H.E. Cramer Co.)	2
	Texas Air Control Board	2
	Bowman Environmental Engineering	1
	California Dept. of Transportation	1
	Colorado State Agency Modelers	1
	Indiana Dept. of Environmental Mgt.	1
	MMS	1
	Radian	1
	South Coast AQMD	1
	Trinity Consultants	1

Table 7, continued. Names of Organizations Used for UNAMAP Support

As a result, the developer is frequently the one called upon to answer technical questions. Regulatory suitability issues have been consistently referred to persons (in OAQPS) who are familiar with the regulations.

Another facet of the problem is that technical support is not the primary activity for EOB personnel. EOB research meteorologists are evaluated on their research efforts in meteorology rather than on their ability to help a novice state agency user through the set-up for a routine ISCLT run.

The remainder of the suggestions reiterate the user's perception of UNAMAP as disjointed and non-standard. Just as there is no single point of contact for support, users see little uniformity in the model components and no attempt to distribute a universally executable model. These two impressions increase the amount of technical support that users want available to them.

4.3.2 Alternatives

There are two approaches to consolidating support activities. One is a decentralized approach with all support activities integrated into the Regional Offices. Support would be closer to the users, and more tailored to local circumstances. In this alternative, Regional Offices have access to EOB and the model clearinghouse in OAQPS when they cannot resolve the question.

One disadvantage to this alternative is that users may see it as further fragmentation of UNAMAP activities. This would particularly affect consultants and industry users who deal with multiple regions.

The second alternative is for centralized support based on the establishment of a Modeling Support Branch within EPA. This staff would have expertise on all the UNAMAP models, a variety of hardware, and would be authorized to convey regulatory requirements when necessary. The support group could communicate with users through a "hot-line" facility or via an electronic bulletin board.

A third alternative is to provide standardized user interfaces, algorithms, and other model components. This approach would help correct the user's perception of UNAMAP as fragmented. A "help" facility included in the code could also reduce support requirements.

4.4 Evaluating Support Alternatives

The critical factor for support activities is the level of service given to users. Goals and standards for the necessary level of service must be determined. Standards could include time for initial response to user, time to solve the problem, frequency of referring user elsewhere, and other related measures. Alternatives must be judged against the level of service provided.

Good user support obviously is worth some price. However, the cost effectiveness must be considered. For each alternative, the value of the difference in service must be compared with the difference in cost.

Support alternatives should also be evaluated in the context of other planned improvements. For example, documentation upgrades would reduce the amount of support required, as would menu and user interfaces. Adding new models to the *Guidelines*, however, would increase calls for support.

4.5 Constraints

The primary constraint is staff resources. Current staffing levels are inadequate to assign dedicated support personnel. Also, the experts required for technical and policy support are not readily available. A support staff training program and/or staff rotation would be necessary.

5.0 DATA COLLECTION

AQSMs use meteorological data usually consisting of hourly meteorological readings to characterize the transport and dispersion conditions at the site. Models also require data about the emission source and about the terrain surrounding the source. Figure 1 shows the types of data required by AQSMs.

Because of the variety of data and the importance to the modeling effort, data collection is a significant part of air quality modeling. Source emission rates, heights, and locations must be derived from engineering calculations for the facility. Background emission inventory data and terrain data are also required in many situations. The data collection effort includes the activities necessary to determine the appropriate data and generate or acquire the data.

There are two sources of meteorological data: data from a National Weather Service (NWS) installation near the site or data collected at the site itself. This section addresses collection problems of both NWS and onsite data.

5.1 Importance of Data Collection

State agency users of UNAMAP rated data collection as a severe problem; consultants and local government users ranked it as a medium-level problem. Industry user rankings were evenly spread through high, medium, and low. One respondent said that data collection and input together took 80-90% of his modeling time (he felt that it should be 5%). Many anecdotes about the problems of data collection were related in interviews.

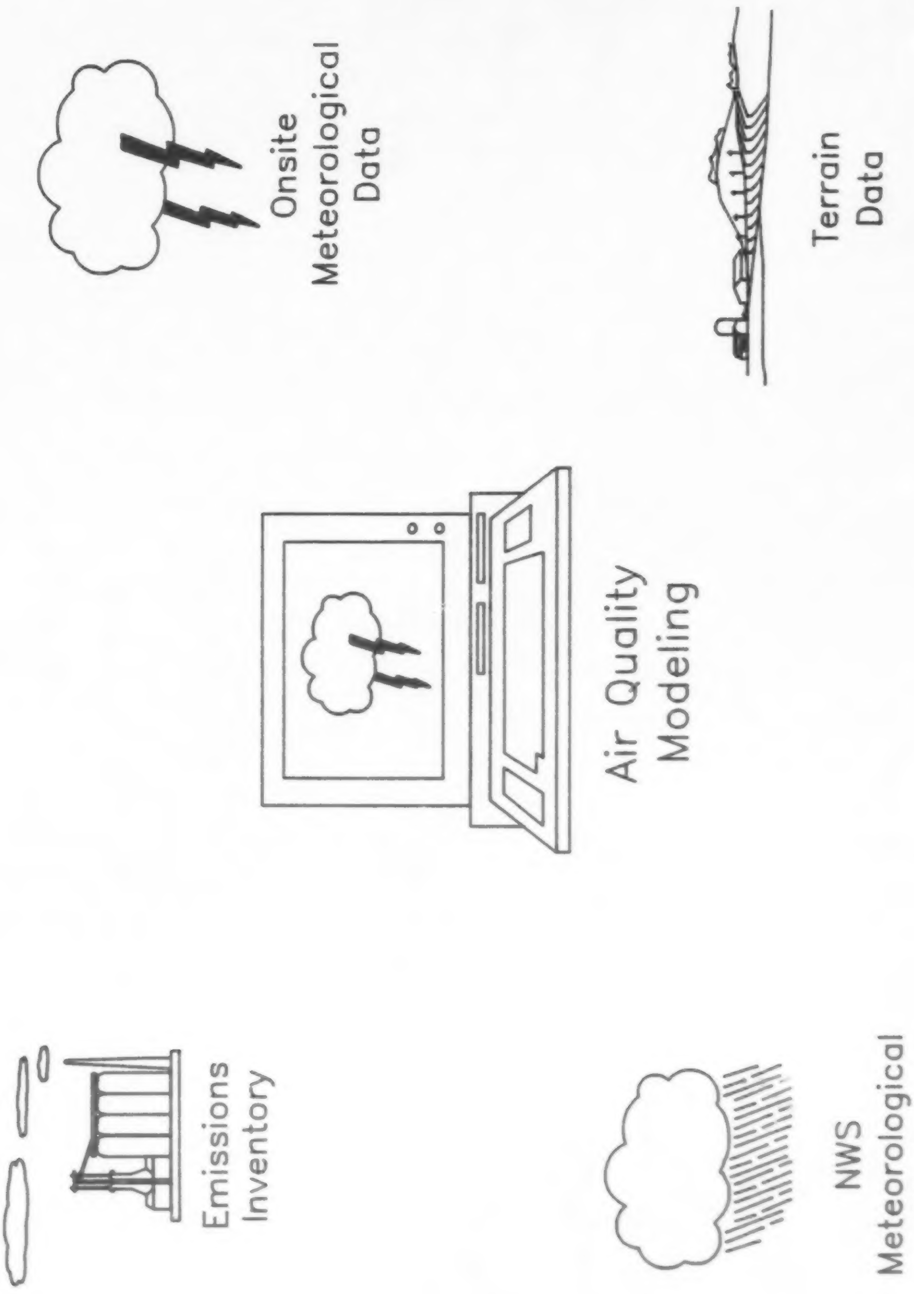
Emissions Inventory
Onsite Meteorological Data
Air Quality Modeling
NWS Meteorological Data
Terrain Data

Figure 1. Types of Data Used by Air Quality Models

5.2 User Suggestions

Users offered a wide range of suggestions for solving their data collection woes. The total of 56 suggestions covered all data collection activities for UNAMAP models. Neither cost nor political difficulty inhibited the suggestions. The major suggestion categories are described below:

- Improvements in the availability of data were suggested in over 21% of the responses. Data availability includes speed of access to the data as well as knowledge of existing data. Most of the suggestions for improved data availability were concerned with NWS and preprocessed data held by EPA.
- Another 21% wanted meterological data collected for more sites or more representative sites. Typically, the reference was to "on-site" data.
- Nearly 20% suggested improving the quality control for existing NWS data. The usual problem mentioned was missing data.
- Nine percent of the suggestions were to collect more, or better, NWS data such as hourly averages or upper air data.
- An additional 9% said that the data should be less expensive.
- Improving source/emission data was in 5% of the suggestions.

5.3 User Concerns and Alternatives

5.3.1 Concerns

The main complaint of users is that there is no comprehensive source of information on what data are available, and how to get it. This complaint encompasses NWS data, preprocessed data at EPA, and on-site data. Acquiring NWS data from National Climatic Data Center (NCDC) is seen by the user community as a lengthy, cumbersome process. A great deal of time and effort is required to collect on-site data. Since these data most accurately represent the site, use of them should be facilitated in any way possible.

5.3.2 Alternatives

There are a variety of data categorizing and distribution services which a data clearinghouse could offer to the modeling community.

A quick and inexpensive alternative is to use a newsletter format to provide, for example, a list of preprocessed data available through OAQPS and a description of NCDC ordering procedures. Users could contribute their knowledge and references of data to subsequent issues. In addition to NWS meteorological data, a clearinghouse could provide references to other publicly funded data such as the National Emissions Data Bank, state monitoring station data, and USGS terrain data. References to on-site meteorological data collected at private expense could be maintained to facilitate the re-use of on-site data whenever possible.

A more elaborate option is to establish the data clearinghouse as part of an electronic bulletin board system. As in the paper alternative, existing data would be listed, including items submitted by users. An electronic system, however, would allow any data available to the bulletin board host computer to be downloaded by users.

The services to be provided and the medium of communication depend on the amount of initial effort required. An inventory of preprocessed NWS data at OAQPS should be easily obtained, but a list of privately funded, on-site data is much more difficult. The utility of monitoring station data may be too low to justify including it.

There is one issue regarding the inclusion of private data. EPA must decide whether it is appropriate for a government agency to publicize the availability of private data when the owner of the data may charge for its use. The cost of ensuring equal treatment to all owners and potential users must be included in the evaluation.

5.4 Constraints

The amount of data available to the clearinghouse may constrain its services or medium. Too little data will make the entire effort unproductive; too much data may overwhelm a bulletin board system or its host computer.

6.0 DATA INPUT

After data collection is complete, the data are not yet ready for use. The data input process includes activities to resolve various meteorological or source data problems, putting the meteorological data into the proper format, and entering receptor and possibly other terrain data. Data input is often a manual function which requires a great deal of user time and effort, but little modeling expertise. Preprocessors (programs used to distill the data) can correct several types of data problems. For example, all parameters needed by the models are not directly measured. Preprocessors are used to produce these parameters as well as take care of other data problems such as calms or missing data.

Simulation models, like most other software, expect data to be presented in a specific fashion. Since models were developed independently, data input methods vary from model to model. There are two general formats for AQSM's: fixed and free format. Those models with a fixed format require that the data be input in a strictly defined way which is specific to that model and extremely inflexible. The input requirements for free format, while less restrictive, still are not consistent among models. To solve the inconsistency problem, microcomputer models have interactive, user-friendly programs which lead users through the data entry process.

6.1 Importance of Data Input

Data input is a problem for novice or infrequent users. They must expend a great deal of effort in determining how to enter data for each specific model. Of the questionnaire respondents, 46% ranked data input as a medium or high level problem, and 60% of those interviewed mentioned some problem with this area. As is shown in Table 4 (see p. III-14), government users ranked data input as more of a problem than did private industry or consultants.

6.2 User Suggestions

There were 49 suggestions made to improve or ease the input of meteorological data into UNAMAP models. User suggestions covered the following categories:

- Forty percent of the suggestions were for a user-friendly front-end program to make data input easier. One user also suggested a data checker to catch errors before running the model.

- Twenty-five percent of the suggestions requested better handling of certain data problems (e.g., missing data and overstrikes in NWS data). Better handling of on-site and complex terrain data were also requested. The increased amount of elevation and coordinate data in complex terrain situations is cumbersome in many UNAMAP models.

- Seventeen percent of the suggestions were for a consistent data input format from model to model and another 6% wanted free format input into all models.

- Eight percent concerned better documentation to aid users when inputting data.

6.3 User Concerns and Alternatives

6.3.1 Concerns

From the suggestions, we conclude that UNAMAP users think data input can and should be made easier. The majority of suggestions were for ease of use improvement; only 25% were concerned with better handling of specific types of data.

6.3.2 Alternatives

As discussed in the Technology Assessment, the UNAMAP user is increasingly likely to be a novice or inexperienced user. Therefore, data input must be made easier. There are three alternative approaches: change the data, change the models, or provide an interface between data and models.

Changing the data would require providing data in the multiplicity of formats required by the various models. The second approach would change varying data input requirements for all models into one, standardized format. The third alternative would require a program which first prompts users for input data, then structures that data into the format required by the model being used.

6.4 Evaluating Data Input Alternatives

The major criterion is benefit to the users. Using AQSM's is a process requiring many steps. While experienced modelers have less difficulty with data input, the trend in modeling is toward more novice and infrequent users. These users are more likely to become frustrated when too much effort is required in an activity preceived to be relatively simplistic.

6.5 Constraints

The main constraint for data input alternatives is the level of effort required to implement the various approaches. In the first alternative, processing and storing data for different models would increase processing time for data providers as well as adding to data storage and distribution costs. The second alternative for data-compatible versions of each model would require extensive programming and testing. The third alternative, a user-interface program, would also require a great deal of programming time including a distinct version for each type of hardware supported.

For an interface program, hardware compatibility must be evaluated. Just as each type of hardware must have its own version of the model, any screen-oriented user-interface programs will require distinct hardware versions.

7.0 HARDWARE COMPATIBILITY

Of the twelve possible problem areas on the questionnaire, three concerned hardware: hardware access, hardware reliability, and hardware compatibility. The majority of respondents ranked hardware access and reliability as minor problems. Hardware access was ranked as a low level problem by 62% of the respondents, and reliability was given a low ranking by 71%. Hardware compatibility, however, caused difficulty for many users.

There are many types of hardware used for modeling by the UNAMAP community. Of the 106 questionnaire respondents using mainframe or minicomputers, 43% use IBM computers, 26% use VAX, 19% use UNIVAC, and 44% use one of several other systems. IBM-compatible microcomputers are used by 44% of the respondents, and only 7% have microcomputers which are non-IBM-compatible. See Table 8 for further data on hardware use and availability.

Several hardware versions of UNAMAP are available. Currently, UNAMAP models may be used via timesharing on the National Computer Center (NCC) UNIVAC computer. The UNIVAC version is the standard for the UNAMAP models, and it may be purchased through the National Technical Information System (NTIS) on tape. A variety of UNAMAP models have been converted from the UNIVAC to other hardware. For example, some regions and state agencies convert models for their own use and make these available to others within their area. Also, several private companies have versions of UNAMAP models for sale. For example, HMM provides an IBM version of UNAMAP models. Companies such as Bowman Engineering and Trinity Consultants have developed microcomputer versions.

The standard version of UNAMAP will change. NCC is converting all UNIVAC operations to IBM, and future models will be supported on hardware other than the UNIVAC. However, whatever the standard version, users of other hardware will be required to convert the models.

MAINFRAMES/MINICOMPUTERS USED FOR MODELING BY UNAMAP QUESTIONNAIRE RESPONDENTS:

Availability and Utilization

	IBM			VAX			UNIVAC			Other*		
	On-site	Off-site	Used	On-site	Off-site	Used	On-site	Off-site	Used	On-site	Off-site	Used
State Government	5	12	16	5	2	5	1	10	11	12	4	12
Local Government		1	1					1		7	4	8
Private Industry	9	6	11	8		7	3	2	5	12	1	8
Consultants	5	14	17	7	8	13	1	3	4	8	12	16
Other	2		1	2		2				3		3

*Other brands mentioned include:

AMDAHL
APOLLO
BURROUGHS
CDC CYBER
CRAY
DEC-10,-20, PDP-11
DG
FOUR PHASE
HARRIS
HEWLETT-PACKARD
HONEYWELL
PERKIN ELMER
PRIME
SUN
UNISYS
WANG

Table 8. Types of Computers Used for UNAMAP Modeling

MICROCOMPUTERS, PLOTTERS, AND TELECOMMUNICATIONS EQUIPMENT USED FOR MODELING BY UNAMAP QUESTIONNAIRE RESPONDENTS:

Availability and Utilization

	PC (IBM-compatible)			PC (Not IBM-compatible)			Plotter (Any brand)			Telecomm. Equipment (Any brand)		
	On-site	Off-site	Used	On-site	Off-site	Used	On-site	Off-site	Used	On-site	Off-site	Used
State Government	27		24	5		4	12	4	11	21		14
Local Government	6		5	3	1		4	1	2	4	1	2
Private Industry	14		12	3		2	14		11	11	1	7
Consultants	35	1	5	3		1	18	4	18	22		18
Other	3		1				6		2	3		

Table 8, Continued. Types of Computers Used for UNAMAP Modeling

7.1 Importance of Hardware Compatibility

Of the questionnaire respondents, 52% ranked hardware compatibility as either a medium or high level problem. Although UNAMAP models are available for certain hardware other than UNIVAC, many users go through the conversion process. This is time-consuming, labor intensive, and prone to error. It is, also, the main reason many users cited for not changing to newer versions of UNAMAP. Table 9 shows data on version number and source of UNAMAP models as reported by users.

7.2 User Suggestions

There were a total of 47 user suggestions on improving hardware compatibility. Of these suggestions, 30% wanted an IBM mainframe version, 30% suggested a microcomputer version, and 21% requested other hardware versions. One user suggested that EPA finance the conversion of models by states. Another user suggested that hardware to run models be available in Regional Offices which would cut down on the variety of computer versions needed.

7.3 User Concerns and Alternatives

7.3.1 Concerns

When UNAMAP models were first developed, many people used them on the computer at NCC. Now, however, due to increased computer availability to users and long turnaround time at NCC, modelers want the software available on their local computers. Although the switch to IBM will be compatible with many users, other hardware versions of certain models will still be needed.

7.3.2 Alternatives

Alternative approaches to increase hardware compatibility fall into two categories: support multiple hardware or make the conversion process easier. Supporting multiple hardware would require that EOB make versions of UNAMAP available on the most commonly used machines.

VERSION NUMBER AND SOURCE OF MODELS BY INDUSTRY GROUP:

For Most Frequently Used UNAMAP Models

MODEL	INDUSTRY GROUP	VERSION		HOW OBTAINED		FREQUENCY OF USE	
		Version Number	Frequency*	Source	Frequency*	Avg. # times used per year	Range (# times per year)
ISC	State Government	6	11	EPA	6	173	2-1000
		5	8	EPA Regional	5		
		4	6	NCC	3		
				NTIS	2		
				HMM	2		
				Trinity	2		
				Other	2		
	Local Government	5	1	EPA	1	1	
	Private Industry	5	5	NTIS	4	31	1-140
				EPA	3		
				HMM	1		
	Consultants	6	13	NTIS	15	283	1-5200
		5	14	EPA	5		
		4	6	NCC	1		
		3	1	Bowman	1		
		2	1				
		1	1				
	Other			EPA	1	4	

* Number of respondents

Table 9. Version Number and Source of Models Used

VERSION NUMBER AND SOURCE OF MODELS BY INDUSTRY GROUP:

For Most Frequently Used UNAMAP Models

MODEL	INDUSTRY GROUP	VERSION		HOW OBTAINED		FREQUENCY OF USE	
		Version Number	Frequency*	Source	Frequency*	Avg. # times used per year	Range (# times per year)
PTPLU/PTMAX	State Government	6	1	EPA	2	110	24-260
		5	1	EPA Regional	1		
		4	2	NTIS	1		
	Local Government	5	1	NTIS	1	18	
		2	1	Trinity	1		
	Private Industry	5	1	EPA	1	9	5-12
		4	1	Other	1		
	Consultants	5	1			52	
VALLEY	State Government	6	3	EPA	2	30	3-104
		5	3	EPA Regional	1		
		4	3	Trinity	1		
		3	2				
	Consultants	5	1			1	

* Number of respondents

Table 9, Continued. Version Number and Source of Models Used

VERSION NUMBER AND SOURCE OF MODELS BY INDUSTRY GROUP:

For Most Frequently Used UNAMAP Models

MODEL	INDUSTRY GROUP	VERSION		HOW OBTAINED		FREQUENCY OF USE	
		Version Number	Frequency*	Source	Frequency*	Avg. # times used per year	Range (# times per year)
COMPLEX I&II	Private Industry	5	1	EPA	1	260	
	Consultants	5	1	NTIS	1	24	
CRSTER	Local Government	5	1			10	
	Private Industry	6 5	1 2	NTIS EPA	2 1	17	1-48
	Consultants			NTIS	1	1	
MPTER	State Government			EPA	1	52	
	Private Industry	5	1	NTIS	1	24	
	Consultants	5	1			104	

* Number of respondents

Table 9, Continued. Version Number and Source of Models Used

There are two ways in which the conversion process can be made easier. First, conversion instructions could be written for all types of hardware. Another alternative would remove all machine-specific code from the models, thus reducing the conversion process to a very simple, mechanical exercise.

7.4 Evaluating Hardware Compatibility Alternatives

Choice among hardware compatibility alternatives must be based on cost effectiveness and usefulness to the modeling community. Support of multiple types of hardware would benefit the users, but would be extremely costly in terms of resources.

Providing conversion instructions for various computers would take roughly the same amount of effort as that necessary to produce different versions. The instructions would ease the conversion process, but time and effort would still be required by each site. Taking machine-specific code out of the models may not solve all conversion problems encountered by users, and would require a major programming effort.

7.5 Constraints

Resources are major constraints on hardware compatibility alternatives. The ideal hardware compatibility solution would provide a version of the UNAMAP models for every type of hardware used by the modeling community. This ideal cannot be met with current staffing levels. Only a very few versions can be written and maintained.

8.0 OTHER AREAS OF CONCERN

Other aspects of the modeling process, while not a problem for the majority of users, were of concern to certain respondents. Three problem areas were mentioned most frequently: response time, output format, and addition of specific models to UNAMAP. Interestingly, output format and addition of specific models were not listed on the questionnaire in advance. These were identified by users when discussing problems other than those listed. All three problem areas are discussed briefly in this section.

8.1 Response Time

Response time is the time needed for the modeling software to produce results after model setup and data input have been accomplished. The response time reported by users varied depending on the size of the computer, the number of simultaneous jobs, and the specific model used.

Although many questionnaire respondents (46%) said response time was only a minor problem, 29% ranked it as a medium to severe problem. This range of responses is due to the variety of computer configurations used. Some users reported that the size of some models caused overnight execution for models run on NCC and other shared mainframe computers. Running some models on a microcomputer also takes several hours.

Solutions to improving response time are faster (i.e., bigger) computers or faster software. Although running models on microcomputers does not decrease execution time, the user has control over when the job is processed. While running the model overnight on a microcomputer will give optimum use of hardware -- and possibly the same response time as a mainframe job -- the user may choose to start the job immediately. Even though it will tie up his microcomputer for several hours, the output will be available that day for study. As a result, another model run may then be performed immediately.

The software can be modified so that it will execute faster to improve response time. Some models would run faster if the code were more efficient. This would require re-writing the models using new programming techniques and look-up tables to decrease the processing time. Another approach would be to make certain calculations optional so that only the processing needed for that specific application is performed.

Evaluation of response time solutions must be based on the degree of improvement achieved, cost effectiveness of the approach, and general applicability of the improvement. Modification of software is the most costly and time-consuming approach. If models are re-written for other purposes, they could be made more efficient at the same time. The improvement of response time alone, however, may not be cost effective. Response time for microcomputer versions of models can be improved by increasing the power of the computer (e.g., 80386 based). As microcomputer costs decline, this alternative promises to give a large benefit for the cost involved.

8.2 Output

Users report that printed results from UNAMAP are confusing, voluminous, and not consistent from model to model. Users suggested that the output can be improved by changing the format of output, giving summaries of data, and by providing more graphics. Specific suggestions on format changes included:

- Make output consistent from model to model
- Print in columns (not blocks) so that multiple runs can be compared easily
- Print up to 50 sources per page
- Print numbers in scientific notation
- Show peak concentration for each meteorological scenario
- Provide running averages rather than block averages

Data summaries would cut down on the amount of output, and allow users to spot problem areas quickly. Output time and costs would be reduced if users were then permitted to request more detailed data on individual items or specific types of printouts such as the data required for regulatory use. Graphics would also reduce the amount of output required and increase its usefulness, particularly to decision makers.

Reformatting the output to be consistent across all models would require programming time. Using a post-processor to re-format output from each model would require less programming time than re-writing each model. Executing the post-processor, however, would increase response time.

8.3 Specific Models

Modelers want changes to current models, and they want models for new purposes. To gather a picture of current model usage, both the questionnaire and interview guide have questions regarding the UNAMAP and non-UNAMAP models used. Table 10 shows that more UNAMAP models were listed by questionnaire respondents than exist in the current version. Some of these models are in the Guidelines but are not part of UNAMAP such as the Texas models and Urban Airshed Model, while others were possibly part of past versions of UNAMAP. Some models listed by respondents as non-UNAMAP are actually UNAMAP, but are listed in the Table exactly as users perceived them. Table 11 lists most frequently used UNAMAP models.

Users suggested that current models be modified to handle the following situations:

- plume meandering
- multiple small sources
- sources closer than 100 meters
- plume rise of almost zero

MODELS MENTIONED IN RESPONSE TO QUESTION ON UNAMAP MODEL USAGE

BLP
CALINE 3
CALMPRO
CDM
COMPLEX I & II
CRSTER
EKMA
HEM
HIWAY2
INPUFF
ISC (ISCLT & ISCST)
MESOPUFF
MOBILE3
MPTER
PAL
PLUVUE
PTDIS
PTMAX
PTMTP
PTPLU
RAM
SHORTZ/LONGZ
TCM-2
TEM-8
TERRAIN
TEXAS CLIMATOLOGICAL MODEL
TEXAS EPISODIC MODEL
UAM
UTMCON
VALLEY

Table 10. More UNAMAP Models Listed Than Exist

MODELS MENTIONED IN RESPONSE TO QUESTION

ON NON-UNAMAP MODEL USAGE

AIRDOS
ADISP
AIRSHED
ARAC
AVACTA II
AQDM
BUGGR
CALINE
CALINE 3Q
CALINE 4
CALQ3
CANNY
CAVITY
CDMW
CHARM
COBUGGR
COMPLEX-IM
COOLMOD
DEGADIS
DM03 & DM04
EKMA 1OZIPP
ESEERCO
GAMMA DOSE
GAUSS 8D
GEMS
HARM
HASTE
HIWAY
HUMAN EXPOSURE MODEL
HWYEM ICOVOL9
Hybrid Plume Dispersion
IMM
IMPACT
LIRAQ
MARYLAND PPSP
MESOPUFF A
MOBILE 3
MPTER-Urban
MSPUFF
MULTIMAX
NYSDEC
OCD
OZIPM-Z
PATHRAE
PAVAN
PHLCO
PLM STAR
PTFUM
PTPLU
PUFF SA
Reactive Plume Model
RPM-II
RTDM
SHORTZ
SPILLS
STAR
STRAJ
TCM
TEM
TEM 8
TEXAS EPISODIC
TEXIN
TRACE
UAM
URBAN AIRSHED/PARIS
VIS LEL1
WCAPCD
XOQDOQ

Table 10, Continued. More UNAMAP Models Listed Than Exist

MOST FREQUENTLY USED UNAMAP MODELS:

Models Used by Ten or More Respondents

Model	# of Respondents Who Use This Model
ISC (ISCLT & ISCST)	81
PTPLU & PTMAX	55
CRSTER	35
VALLEY	33
COMPLEX I & II	31
MPTER	22

Table 11. Most Frequently Used UNAMAP Models

Users also requested new models to fill the following needs:

- More screening models (less complicated, easier to use, and faster to run)
- Refined complex terrain model which addresses lee side concentrations
- Generic lake/sea breeze model
- More ozone models
- Heavier-than-air models
- Toxic models
- Non-steady state models

The Environmental Operations Branch (EOB) has limited responsibility for the heavier-than-air and toxic models. However, users see UNAMAP as the vehicle for all their modeling needs and expect EOB to be as responsive to these needs as they have been to past needs. For non-steady state applications, a UNAMAP model, INPUFF, is already available. It is not, however, a Guideline model.

9.0 GENERAL CONSTRAINTS

Any alternative for improving UNAMAP is subject to some external constraints. These constraints make up the technological, economic, and regulatory environment in which UNAMAP presently exists and the environment in which it must exist in the future.

9.1 Technological Constraints: Computer Resources

Three computer environments will be available for the future development and support of UNAMAP. Traditionally, computer resources were provided by EPA's National Computing Center (NCC) on a UNIVAC 1100 series mainframe. However, the NCC is migrating all applications from the UNIVAC to an IBM 3090 system. The conversion is scheduled for completion by October, 1988.

The Meteorology Division recently acquired a DEC MicroVax II multi-user microcomputer, terminals, and local area networking (LAN) system. Many UNAMAP models have been converted to the MicroVax, and most internal model development is currently done on that system.

As shown in Table 8 (see p. III-42), microcomputers, specifically IBM PC/XTs and compatibles, are becoming widely available to UNAMAP developers and users. One UNAMAP model (INPUFF) was originally distributed in a microcomputer version. This model is now available on the UNAMAP version 6 tape.

These three computer environments (IBM Mainframe, DEC VAX, and IBM PC) represent the most widely used systems in the world today. They offer a variety of capacities and price ranges, and are compatible with the majority of user mainframes (IBM), EPA regional systems (VAX/MicroVax), and office microcomputer systems (IBM PC). Any alternative which involves new computer hardware or software for UNAMAP must consider and utilize some combination of these.

9.2 Economic Constraints: Budget and Staff

Considering its importance and regulatory mandate, UNAMAP operates with very limited resources. There is currently no EPA staff member dedicated full-time to development, enhancement, and/or support of UNAMAP. NOAA research meteorologists assume UNAMAP duties as a collateral assignment. Total funding was approximately \$550K in FY 1986. This amount included \$425K in salary, and \$125K in onsite contractor funding. Although funding increases in future years are possible, immediate improvements to UNAMAP (FY 1988) must be implemented within current budget figures regardless of potential benefits.

9.3 Regulatory Constraints

The authority of EOB is limited to the study of airborne, non-nuclear, criteria pollutants. In addition, models which are to be included in the Guidelines are specified according to a regulatory policy which is somewhat independent of computer or modeling technology or efficiency. To be seriously considered for implementation, any alternative for UNAMAP improvement which involves adding or deleting models must fall under the purview of OAQPS and be consistent with policy as embodied in the Guidelines.

9.4 Future Outlook for Air Quality Modeling and UNAMAP

The success of air quality modeling as an important tool in protecting the environment is now taken for granted by researchers, industry, and regulators. Future development lies in three directions:

1) Solving increasingly complex or large-scale air quality problems, such as regional and complex terrain models;

2) Developing AQSM's to deal with more specialized situations, thereby broadening applicability;

3) Supporting a larger community of regulatory users.

The models used to solve large, complex problems will themselves be large and complex. Large regional models will be used to study dispersion and transport of pollutants, such as acid precipitation ingredients, over large distances. The models must handle multiple wind speeds, wind directions, and atmospheric stability situations. These functions entail a significant increase in model complexity. There will be a smaller number of situations needing such a model. The Urban Airshed Model is a complex urban photochemical model, whose large size kept it from being included on the UNAMAP tape.

AQSM's were originally designed for general use in a variety of situations. As users and developers have become more sophisticated, models have been tailored to meet specific needs. Sites where the terrain is not flat for example, is one area of major concern. Effective air quality modeling in situations require accurate complex terrain models. Some current models can be used in complex terrain, but they are not as sophisticated as the problems they must model. The development of CTDM -- currently underway -- is a reaction to these needs.

New application areas for future models are toxic gases, radiological pollutants, emergency release situations, and offshore sites. For some applications, the addition of new capabilities to current models, rather than a new model, will fill the need. New analytical functions, such as statistics and health-risk assessment factors, will be added to some models. While EOB is responsible for current models, they have no research responsibility for many of these new areas.

Regulatory usage will remain high, and novice or infrequent users will continue to account for a large portion of regulatory use. Because of their lack of experience, user support will be required at a higher level than is currently available. These users will tend to run models on microcomputers or on local or regional hardware with which they are familiar, not on NCC's computer.

To aid these users, data input formats should be standardized to ease the data-entry bottleneck which currently exists. The format of model output should also become more standardized, and models should produce reports which are easily interpreted and quickly generated.

One point which applies to all three directions (model complexity, model specialization, and novice regulatory users) is that the quality of modeling results is inextricably tied to the quality of data available. The lack of automated data gathering instrumentation inhibits the collection of more data per site and at more sites. The manual transfer of data has increased the time spent waiting for data and minimizes the sharing of on-site and NCDC data.

The concept of UNAMAP should change in the near future. To match the trend toward a split between novice users and more sophisticated developer-users, UNAMAP Version 7 (or 8) may do best to exist in two parts. One part would consist of the Appendix A models and documentation directed at the novice who will be using UNAMAP for regulatory purposes. The other UNAMAP would be the remaining, less frequently used, models. This version would include more technical documentation and theoretical background information.

If such a division is made, a corresponding set of changes may be necessary in the distribution mechanism and computer system compatibility of the novice user portion.

10.0 RECOMMENDATIONS

In this section we describe recommendations for the improvement of UNAMAP. The recommendations are not individually intended to address the specific problems described in Sections 2 through 8, but instead will facilitate the growth of UNAMAP in the future and eliminate current problems. Implementation of these recommendations will move toward a new concept of UNAMAP.

The system began as a centralized, timeshared system used by a relatively small group of experienced modelers whose needs were, for the most part, being met. The trend now is toward a more distributed system with modelers using a mix of hardware to meet different modeling requirements. UNAMAP, therefore, must be upgraded and streamlined to meet the needs of a larger, less-experienced user group who are using models to meet increasingly complex problems. The new UNAMAP will also serve the larger user community by providing improved access to model changes, documentation updates and meteorological data. The new "Strategic Vision" for UNAMAP is an acceptance of its evolution.

10.1 Recommendation 1: Establish an Electronic Bulletin Board

10.1.1 Description

A multi-user bulletin board system should be implemented on the MicroVax system. The initial uses of the bulletin board would be to provide UNAMAP support (answers to questions via electronic mail) and to distribute information of value to the UNAMAP community at large. Minor software patches and documentation updates could also be provided over the bulletin board. The services provided could expand as computer resources and communication lines allow. The system could be expanded to allow distribution of new versions or releases of the models, new manuals, and even data.

10.1.2 Benefits

There are significant benefits in an electronic bulletin board system:

- UNAMAP support is removed from reliance on the telephone. The result will be more complete and faster information for users and a more efficient use of support staff time, which will benefit both the user and the support personnel.

- Users can enter their questions into the system without regard to the availability of support staff. Support providers will be freed from the instantaneous demand of the telephone.

- A bulletin board allows for direct communication among all segments of the UNAMAP community. Improved communication, a higher general level of expertise, and a more closely knit user community can occur.

- The bulletin board is the foundation for electronic software distribution and data clearinghouse (see Recommendation 8). Once users and developers are accustomed to electronic transfer of information, more capabilities can be added.

- The time, effort, and cost to distribute new versions, corrections, and updates to UNAMAP models and documentation could be dramatically reduced. Data requests to NCDC typically take two months from initiation to receipt. Similar times are required to order UNAMAP from NTIS. Many of these requests could be answered over the bulletin board within 24 hours.

10.1.3 Time and Cost Estimates

Several bulletin board systems are available. For comparison, any candidate system should offer bulletins, private electronic mail, distribution lists, and file transfer. One such system has been developed by Battelle for DOE and is run on a MicroVax II. To tailor the basic software for EPA, install it on the Meteorology Division MicroVax, and provide system operator training would require:

Bulletin Board S/W: tailored, installed, system manager training and documentation.	Labor Cost: $4,000 - $7,000 Time: 45 days after installation.
Hardware: MicroVax ports (3) and modems (3).	Ports Cost: $1,800 for 8. Modem Cost: $600 each. Time: 30 days after order.
3 telephone lines.	Cost: GSA Cost. Time: 45 days after order.
System management time: in the DOE application, a small amount of time is required for file transfer, update of bulletin boards, and message clean-up.	Staff Time: Approx. 12 hrs/mo.

10.1.4 Alternatives Not Chosen

A PC-based bulletin board system was considered. Such a system would have certain potential advantages, especially within the PC environment. For example, compiled (executable) versions of model code could be transmitted and run on similar PCs without re-compiling. Also, if binary data existed in PC format, it could be transmitted for immediate execution on a similar PC.

Battelle has previous experience with single-user (PC) as well as multi-user bulletin board systems. Because of limitations of the PC-DOS operating system, these systems are only available to a single user at a time on most office PCs. Our experience has shown that as soon as a single-user system becomes well-known, functionally beneficial, and used, it becomes overloaded. This is a source of user frustration, and causes more harm and waste than benefit. Also, a PC-based system would not be able to provide directly executable code or binary data to mainframe computers.

10.2 Recommendation 2: Produce, Distribute, and Support a Series of End-user Documentation

10.2.1 Description

New documentation should be designed, developed, tested, and distributed to end-users. The documentation design and organization would be based on a functional or task orientation. The manuals would be written for the non-technical reader, tested by novice users, and distributed through the EPA Regional Meteorologists. Since so many users depend on the manuals to learn the models, manuals should include some self-paced teaching exercises. Manuals for each Appendix A and B model would be produced, including Complex I and II.

10.2.2 Benefits of End-User Documentation

Although documentation may not appear to be a vital component of AQSMs, it can have a greater operational impact on UNAMAP than such internal model changes as the handling of the receptor grid, for example. High quality, consistent end-user documentation will increase the uniformity of model application. Good documentation will reinforce correct interpretation of results with clear, detailed examples, and reduce the guesswork in most standard modeling situations.

Clear, easy to use documentation will also reduce requirements for direct EPA support to end-users. For example, by prominently featuring answers to the most frequently asked questions or system error messages, improved documentation would free support staff to deal with more difficult questions or to perform other functions.

10.2.3 Time and Cost Estimates

Unless there is a supply of user-documentation specialists available to the Meteorology Division, the initial design and development of end-user manuals for UNAMAP should be done out-of-house. The following is required:

o Design and develop user manuals for 12 Appendix A and B models including task analysis, examples, and self-paced exercises.	Labor Cost: $250,000 - $300,000 Time: 8 to 12 months plus procurement lead time.

10.3 Recommendation 3: Provide UNAMAP Code, Data, and Documentation for Multiple Computers

10.3.1 Description

It is inevitable that modeling will continue its move into a distributed environment with fewer activities done on timeshared mainframes, some moving to local mainframes or minicomputers, and a great deal on microcomputers. Battelle recommends that EPA actively support multiple computers by providing software, data, documentation, and support services for a variety of hardware. UNAMAP software should be available for the following types of computers: IBM mainframes, DEC VAX, and IBM-compatible PCs. These are the computers most frequently used for UNAMAP modeling, (See Section 7). This improvement will directly serve the long-range goals of UNAMAP in many ways. It will make the conversion process either vastly easier or totally unnecessary, which will allow new versions of the models to be executed with less expenditure of time and effort. This ease of upgrading and conversion will in turn encourage the use of non-regulatory models.

The major effort may be providing input data formats that can be run on all three computers. As part of the multiple computer support approach, Battelle recommends that EPA provide, or allow for the use in all models, of preprocessed data in a form that is directly transferable to an ASCII disk file. Also, to simplify conversion and maintenance, a standard PC hardware and software system configuration should be established and communicated to the UNAMAP community.

10.3.2 Benefits

- PCs provide a low-cost, readily available alternative when conversion, compatibility, or access is a problem on mainframes.
- The majority of users surveyed have, and use, IBM mainframes for modeling. Thus, the largest group of users would be spared the conversion process. The number of modelers using obsolete versions of UNAMAP would probably decrease if IBM translations of the current version were available.
- Time-sharing at NCC would decrease. Users overwhelmingly prefer to buy UNAMAP (See Table 12).
- The number of models actually installed and available on a user's mainframe would increase.
- Models could be distributed by an electronic medium or by diskette.
- Some model development, revision, testing, and documentation activities could be performed on PCs and translated to mainframes.
- The VAX line is the second most commonly available mainframe for UNAMAP users and is currently used for modeling by 27% of the users.
- The MicroVax is already being used for EOB UNAMAP development. Thus, little additional conversion of code would be required. This would also facilitate the distribution of models, documentation, and data through the MicroVax bulletin board system.

QUESTIONNAIRE RESPONDENTS' PREFERRED SOURCE OF UNAMAP MODELS

	1st Choice				2nd Choice				3rd Choice				4th Choice			
	RTP Mainframe	NTIS Tape	NTIS Diskettes	Other	RTP Mainframe	NTIS Tape	NTIS Diskettes	Other	RTP Mainframe	NTIS Tape	NTIS Diskettes	Other	RTP Mainframe	NTIS Tape	NTIS Diskettes	Other
State Government	4	14	12	6	10	7	8	4	3	7	9	5	15	4	2	3
Local Government	2	1	3	4	1	4	4		3	2	2		3	2		
Private Industry		12	6	4	2	3	10		5	2	1	1	7	3	2	
Consultants	1	18	13	3	2	9	13	4	11	6	1	3	14	1	3	3
Other		1	1			1	1		1				1			
TOTALS	7	46	35	17	15	24	36	8	23	17	13	9	40	10	7	6

Table 12. Users Prefer to Buy UNAMAP

10.3.3 Disadvantages

- Currently, mainframe-oriented UNAMAP preprocessors do not provide a disk-based ASCII file or the capability to translate into the PC or MicroVax binary storage format. A standard microcomputer configuration would require either such a conversion program or an ASCII (not binary), preprocessed, disk-based (not tape) input file. Transfer and execution of input data on mainframes is commonly done in ASCII, disk-based format as well.

- Moving to multiple development or distribution environments will increase "version control" problems, even if a "universal" approach is taken.

- Users will expect an increasing amount of machine-specific support.

- It may be necessary for the EPA support organization to maintain three UNAMAP environments. Incidently, a PC system requires proportionally as much system management as any large computer system.

- The IBM ANSI FORTRAN compiler may not be available to all sites. Therefore, a compatibility problem may still remain.

10.3.4 Time and Cost Estimates

The following resources will be necessary for development of a "universal" system:

o A minimum of 2 PC configurations with the standard Fortran.	Cost: $6,000 - $8,000 Time: 30 days if purchased commercially.

o Translation of UNIVAC specific versions of UNAMAP models and data preprocessors to IBM, VAX, and IBM PC including documentation.	Cost: $50,000-$75,000 Time: 6 to 9 months, plus procurement lead time.
o Quarter to half time PC systems manager.	Staff Time: 60 hrs/month.

10.4 Recommendation 4: Improve the Accuracy and Technology of Models Included in UNAMAP

10.4.1 Description

Battelle recommends that EPA continue research to improve the predictive capability of dispersion models used by the public. Improving the accuracy of the regulatory models and advancing the modeling technology in UNAMAP are necessary to continue the viability of the program. Although improvements to the accuracy of UNAMAP models will not be cheap or easily accomplished, Battelle recommends that the new UNAMAP include major efforts in this area.

Improving the predictive accuracy of UNAMAP models would be done in three phases. The first phase will be to improve the peer review process used to identify accuracy problems within the current models. Improvements could be gained by involving a greater segment of the UNAMAP community. The second phase is to conduct additional research to correct these problems and improve the models. The research will include more model validation and evaluation activities, within specific situations, for a variety of models. Research will also be done to improve the scientific basis of dispersion modeling. The third phase is to have any improvements incorporated into the regulatory process.

Technical discussions of model accuracy can be provided through the bulletin board and included in the user's manual for each model. Non-technical discussions of accuracy should also be provided through the bulletin board.

10.4.2 Benefits

- The primary benefit of additional accuracy research is that advances in modeling technology will occur through the research activities. This will improve the state of air quality models.
- Increased user knowledge of accuracy and of current research will increase the use and acceptance of new research models.

10.4.3 Time and Cost Estimates

The activities described for improving the accuracy and technology of the UNAMAP models are not easily quantifiable either by cost or level of effort. They represent a direction in which to focus research resources and have the greatest possible impact on UNAMAP users. The UNAMAP modeling community considers these activities to be of the utmost importance.

10.5 Recommendation 5: Develop a Consistent Set of User Interfaces

10.5.1 Description

Battelle recommends that screen-oriented software be added to all UNAMAP models. The goal is to make all models in UNAMAP appear as much alike as possible. All conversions of units, formatting to the model's requirements, decimal conversions, etc. would be performed by the interface. Variations would be required in the software to allow for variations in source characterization, such as end points for line sources, and diameters or corners for area sources. The interface software would determine, based on the model and the options selected, which data was required. The interface would ensure that the data was put into the input file in the format needed by that model.

10.5.2 Benefits

- These interfaces will ease the data input and model setup burden, thus making UNAMAP models easier to use.
- By providing a similar interface across regulatory and research models, the use of the non-regulatory models will be encouraged.

10.5.3 Disadvantages

- Because screen-oriented software is specific to a given type of terminal, separate versions may be required for each type of hardware (i.e. IBM, VAX, and PC) supported.
- The effort required to provide interfaces to all models and in all hardware versions is significant.
- A screen-oriented interface residing on an IBM mainframe would require that users have a terminal capable of interpreting IBM 3270 protocol.

10.5.4 Time and Cost Estimates

The costs below are in terms of estimated contract rates for systems analysts and senior programmers. Hourly estimates are given so that EPA can estimate the level of effort to perform the work, regardless of whether or not it is contracted. The estimates below are for one hardware version only. They should be adequate for any of the three environments.

o Develop Specifications for 12 highest priority UNAMAP Models.	360 hours analyst Labor Cost: $21,600 Time: 90 days
o Develop Interfaces for 12 highest priority UNAMAP Models.	540 hours programmer Labor Cost: $32,400 Time: 180 days

o Develop Specifications for 12 remaining UNAMAP Models.	300 hours analyst Labor Cost: $18,000 Time: 75 days
o Develop Interfaces for 12 remaining UNAMAP Models.	450 hours programmer Total Cost: $27,000 Time: 120 days

10.6 Recommendation 6: Consolidate All Support for UNAMAP Models

10.6.1 Description

A single support group should be established to provide a unified voice on model application, technical issues, data appropriateness, and regulatory requirements to the users. This could be a telephone "hot line", an electronic mailbox address, a newsletter, or any combination. The support group and method of contact would be publicized and communicated to users. This group would act as the first line of support in all UNAMAP modeling areas, and would draw on advice from specific experts as required.

10.6.2 Benefits

Two primary benefits accrue from consolidating user support: better direct service to users, and furthering the EPA goal of consistency. By providing a single point of contact, the user effort and time needed for a response to a question or problem would be reduced. The user would always know who to contact and the support group would decide whether they could answer the question or refer the user to the outside expert who was most qualified. By being fulltime, the support staff would quickly gain expertise, thus improving response time to the user. Consolidated support will provide consistent responses to the users. A single source for support means that the same question tends to get the same answer every time. Also, the support task will become easier as the staff gains experience. Once a question is answered or an issue resolved, that information becomes part of the support group's knowledge base (preferably in an automated troubleshooting log). The knowledge is in place whenever a similar question or issue arises again.

10.6.3 Time and Cost Estimates

Current support time and costs are difficult to estimate for two reasons. First, support is currently fragmented among the regions, OAQPS, and ORD thus making it difficult to compile figures on the support effort expended. Second, the demand for support in the future will fluctuate significantly as changes are made. For example, conversion to IBM 3090 will increase support requirements; better documentation will reduce requirements. The following estimates are based on present conditions:

o Plan and establish support system, including training.	Staff time: 12 person-months
o PC, Software, and terminal.	Equipment Cost: $5,000
o Operate support branch.	Staff time: 300 hrs/month
o Associated equipment: two telephone lines with answering machines (or data communications equipment).	Equipment Cost: $1,000

10.7 Recommendation 7: Establish a Meteorology Data Clearinghouse

10.7.1 Description

A data clearinghouse should be established to provide a central source of information about the availability of meteorological data. It should include information about onsite data as well as NWS data. The availability of preprocessed data should also be included. This clearinghouse could operate as part of an electronic bulletin board system on the Meteorology Division MicroVax. When available, data could be transmitted electronically.

10.7.2 Benefits

- The time spent waiting to acquire data could be dramatically reduced in some cases. For example, data currently managed by OAQPS could be translated and copied to the MicroVax, then downloaded to the user's mainframe or PC for inclusion in a modeling project, all within the same working day.

- The existence of onsite data could be made known to potential, secondary users. Even if the data are proprietary, a contact point for the owner would be provided. In some cases, the owner might transmit the data to the clearinghouse for forwarding to the secondary user.

- Emission inventories, topographic data, and other data could all be made available from a single source in a standardized format.

10.7.3 Time and Cost Estimates

This recommendation is seen to be an internal EPA task; therefore, all estimates are in terms of staff time. Elapsed time estimates make allowances for response from other parties where necessary.

o Collect information from data providers, including lists of data available, formats, locations, costs.	Staff Time: 200 hours over 3 months.
o Set up bulletin board area, including bulletin board specifications for each different data source, load data (if applicable), and test.	Staff Time: 64 hours for each data source. Time: 30 days

o Publicize the service to users, including preparation of initial newsletter and user documentation for bulletin board area.	Staff Time: 72 hours Time: 30 days

10.8 Recommendation 8: Develop or Acquire Specialized Models for Inclusion in UNAMAP

10.8.1 Description

Battelle recommends that EPA provide specialized models as part of the UNAMAP library to help the modeling community fulfill all aspects of their obligation to protect the environment. Specialized models will be designed for use in situations which are handled poorly or not at all by the current UNAMAP models. These models may need different modeling algorithms or new functions such as human exposure or health risk assessment.

To stay abreast of current trends in AQSM, and to increase the applicability of UNAMAP models, ORD should concentrate development resources on models in the following areas:

- Shore Breeze
- Complex Terrain
- Spills with Evaporation
- Toxic Gases
- Heavy Gas Models
- Health and Vegetation Effects

Not all these areas are within ORD's current sphere of responsibility. The first two are logical extensions of existing criteria pollutant dispersion modeling. The CTDM model is a refined complex terrain model currently under development by ORD.

Toxic gas and spills with evaporation are not clearly within ORD's area. Models dealing with these problems, however, are in demand by state government, private industry, and consultant users. The modeling community looks to UNAMAP to meet their expanded modeling needs. ORD has the centralized expertise to develop these models as well as the respect and influence within the modeling community and regulatory circles to carry out such a project.

10.8.2 Benefits

- Shore breeze and complex terrain models would improve the accuracy and credibility of EPA's regulatory modeling efforts. The current "work arounds" and adaptation of other models would be eliminated.

- Evaporation and toxic gas models have been developed outside of EPA. By acquiring rights or licenses to such models, ORD can gain exposure to new types of models and expand their availability to the public.

10.8.3 Time and Cost Estimates

Such models can either be developed or acquired. Model development cost depends, of course, on the specifications which are to be met. The tasks required to develop these models are familiar to EPA. One of the specialized models, complex terrain, is already under development by EPA; thus, its cost should be fairly well determined.

While the cost of acquiring an existing model is easier to estimate, other costs must be included. Acquisition estimates should include the following:

- Purchase rights or license
- Installation or conversion of the model
- Learning to use and support the model
- Preparation of documentation

Total estimated cost per model: $20,000
Availability to users: 6 to 9 months

10.9 Recommendation 9: Support the Collection of Additional and More Accurate Meteorological Data

10.9.1 Description

Battelle recommends that EPA work closely with NWS, other government agencies, and industry to promote the collection and dissemination of meteorological data which will facilitate the advancement of dispersion modeling technology.

10.9.2 Benefits

There are no specific quantifiable activities which will guarantee that improved meteorological data is captured. Rather, this recommendation is for EPA to press for data improvements through publicity, research, interagency agreements and regulatory changes. By increasing awareness throughout the air quality modeling community, EPA could increase public support for data collection improvements. A proportion of ASRL research could focus on the impact of data on model results. Increased cooperation with the government agencies responsible for meteorological data collection may eventually result in better data being available to UNAMAP modelers. In addition to NWS, approaches to NRC, DOE, and DoD may result in improved modeling data, at least for certain locations.

The Meteorology Division should continue to work closely with OAQPS to see that the best possible data is applied to modeling in the regulatory environment. This may take the form of additions to the guideline models, or the allowance of modifications to certain models.

As data may be the limiting factor in improving the accuracy of models in UNAMAP, improvement in the data available will contribute to the goal of advancing research in modeling. Also, as data contributes to improved accuracy, it will increase the credibility of modeling to industry and the public.

10.9.3 Estimated Cost and Time

The initiatives described above do not have a directly quantifiable cost or level of effort. They represent a certain direction in which to focus both research and management communication resources. Although the resources of the Meteorology Division are extremely limited, the importance of this area dictates that EPA implement some program to improve the data available for air quality modeling.

10.10 Recommendation 10: Support the Electronic Transfer of UNAMAP Documentation

10.10.1 Description

Battelle recommends that EPA make UNAMAP documentation available to modelers through electronic file transfer. The electronic documentation could be supported on the bulletin board system (See Section 10.1). Users could download a copy of any UNAMAP model's current documentation whenever needed. Then, paper output and reproduction would be under the control of the user. Updates could be incorporated into the user's copy as needed.

10.10.2 Benefits

Electronic availability would greatly speed the dissemination of documentation, both in the original form and for updates. This improvement increases the extent of UNAMAP support offered through a central location. Indirectly, the use of non-regulatory models is facilitated through increased awareness and accessibility of their documentation.

10.10.3 Time and Cost Estimates

The major effort associated with this improvement will be to develop the format specifications and any format conversion programs which may be required. If this recommendation is implemented in concert with the documentation changes in Section 4.2, the UNAMAP documentation will be revised and will then exist in some electronic form. The costs attributable to this recommendation are then limited to selecting and publicizing the standard packages.

o Select standard graphics and word processing packages.	Labor Cost: $5,000 - $6,000 Software Cost: $1,000/copy Time: 60 days
o Publicize standards to users (distribute newsletter to users and put on bulletin board).	Labor Cost: $2,400 Time: 20 days

11.0 ALTERNATIVES NOT RECOMMENDED

Several suggestions and alternatives are not included in our recommendations. These are briefly discussed in this section.

11.1 Graphics Output for Models

The graphics standards and output capability of users vary widely. This issue is most easily resolved in the PC environment, where the EGA display and HP 7475 plotter are defacto standards. Bowman, Cleary, and Trinity are providing good products in this area.

11.2 Improving Response Time

Modeling on microcomputers will increase and the computers will become faster. These factors will make response time for UNAMAP-scale AQSMs less of an issue. Larger, more complex models, however, must address the execution time issue as they are developed.

12.0 SUMMARY

This Interim Report has reported the results of the UNAMAP interviews and questionnaire, described the users' concerns in detail, and specified Battelle's recommendations for improvements in all aspects of the UNAMAP program.

The variety of problems and suggestions provided by UNAMAP users served to identify areas where the UNAMAP program needs improvement to provide better service to the air quality modeling community. The list of major problems included both technical concerns (such as model accuracy) and non-technical issues (such as user support).

Ten recommended improvements were described in the report. For each recommendation, its benefits over the present system were listed. The disadvantages of some recommendations were identified where significant. Time and cost estimates were generated for each improvement. Taken in their entirety, the recommendations included in this report can greatly increase the accessibility of UNAMAP and improve the models' ease of use.

Appendix A: Interview Guide

Name:____

Organization:____

UNAMAP INTERVIEW GUIDE

BACKGROUND

1. Would you give us your job title:

Title:____

2. What is the nature of your involvement with UNAMAP or other AQSMs:

User	Developer	Software support
Data provider	Remarketer	Validator
None	Other________________________________	

3. Have you worked for other organizations where you were involved with AQSMs?

______yes ______no

If "yes", what were the organizations and what was your involvement (use the categories above):

ORGANIZATION	INVOLVEMENT

4. How long have you been involved with AQSMs?__________________________

5. Which UNAMAP models have you been involved with:

USED HOW LONG?	UNAMAP MODEL	# TIMES YOU USE MODEL
____________		
1 yr. or less	MODEL NAME:____________________	____ per week
____________	____________________	
2-4 years	VERSION #:____________________	____ per month
____________	SUBROUTINES USED:____________	
5 years or less	____________________	____ per year

Briefly describe any modifications you've made to the model:____________________

____

USED HOW LONG?	UNAMAP MODEL	# TIMES YOU USE MODEL
____________		
1 yr. or less	MODEL NAME:____________________	____ per week
____________	____________________	
2-4 years	VERSION #:____________________	____ per month
____________	SUBROUTINES USED:____________	
5 years or less	____________________	____ per year

Briefly describe any modifications you've made to the model:____________________

____

____

USED HOW LONG?	UNAMAP MODEL	# TIMES YOU USE MODEL
____________		
1 yr. or less	MODEL NAME:____________________	____ per week
____________	____________________	
2-4 years	VERSION #:____________________	____ per month
____________	SUBROUTINES USED:____________	
5 years or less	____________________	____ per year

Briefly describe any modifications you've made to the model:____________________

____

____

USED HOW LONG?	UNAMAP MODEL	# TIMES YOU USE MODEL
1 yr. or less	MODEL NAME:________________	____ per week
	________________	
2-4 years	VERSION #:________________	____ per month
	SUBROUTINES USED:________________	
5 years or less	________________	____ per year

Briefly describe any modifications you've made to the model:________________

____

____

6. Which non-UNAMAP models have you been involved with:

USED HOW LONG?	NON-UNAMAP MODEL	# TIMES YOU USE MODEL
1 yr. or less	MODEL NAME:________________	____ per week
	________________	
2-4 years	VERSION #:________________	____ per month
	SUBROUTINES USED:________________	
5 years or less	________________	____ per year
	Have you modified the model? Yes No	

Main purpose of the model (e.g., predicts CO concentrations):________________

____

Who developed the model:________________

Briefly describe any advantages this model has over UNAMAP:________________

____

____

USED HOW LONG?	NON-UNAMAP MODEL	# TIMES YOU USE MODEL
1 yr. or less	MODEL NAME:________________	____ per week
	________________	
2-4 years	VERSION #:________________	____ per month
	SUBROUTINES USED:________________	
5 years or less	________________	____ per year
	Have you modified the model? Yes No	

Main purpose of the model (e.g., predicts CO concentrations):____________________

____

Who developed the model:____

Briefly describe any advantages this model has over UNAMAP:________________

____

____

USED HOW LONG?	NON-UNAMAP MODEL	# TIMES YOU USE MODEL
1 yr. or less	MODEL NAME:____________________	____ per week
2-4 years	VERSION #:____________________	____ per month
	SUBROUTINES USED:______________	
5 years or less	______________________________	____ per year
	Have you modified the model? Yes No	

Main purpose of the model (e.g., predicts CO concentrations):____________________

____

Who developed the model:____

Briefly describe any advantages this model has over UNAMAP:________________

____

____

****

INTERVIEWER:If interviewee is not a user of AQSM, skip to 2.4.b on page ______.

****

7. Following are some of the processes involved in using AQSMs. Review with us the steps you follow and the information you use in these proceses:

What are the factors which influence your decision to use AQSM:

____

____

____

____

% of projects where you use AQSMs:______________________________

****

INTERVIEWER: Be sure the following points are included for each:

PROCESS	% TIME SPENT	STEPS FOLLOWED	INFORMATION USED

****

Choosing a model:____

____

____

____

____

Collecting data:____

____

____

____

____

____

Waiting/Arranging for
computer access:____

____

____

____

____

____

Inputting data/
model parameters:____

____

____

____

____

____

Waiting for result/
printing: ____________________

____

____

____

____

____

Verifying
output format: ____________________

____

____

____

____

____

Using/interpreting
output : ____________________

____

____

____

____

____

8. Is the product of the AQSMs worth the costs (time, money, etc.)?

____

9. How important is UNAMAP or other models to your job? ____________________

____

11. How would you do your job without UNAMAP or other models? ____________________

____

12. What is the hardest part of using the models? ____________________

____

____

____

____

****

INTERVIEWER: Use this section for all categories other than USERS of AQSMs otherwise skip to page #

****

13. Describe the different processes you go through in fulfilling your role with UNAMAP or other models.

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

9. How important is UNAMAP or other models to your job?______________________

____

11. How would you do your job without UNAMAP or other models?________________

____

12. How did you learn about the models(s):

****

INTERVIEWER: Use the following codes for training methods:

T = Training course, seminar, workshop   S = Self-taught

U = University course while pursuing degree   O = One-on-one training by co-worke

****

MODEL	TRAINING METHOD	DIFFICULTY IN LEARNING
______________	T U S O	______________
______________	T U S O	______________
______________	T U S O	______________
______________	T U S O	______________
______________	T U S O	______________
______________	T U S O	______________
______________	T U S O	______________
______________	T U S O	______________

Rank the models on the difficulty you experienced in learning them (i.e., which model was easiest to learn, which was the next easiest, etc.).

****

INTERVIEWER: If the following question is answered YES skip to the questions for that response; otherwise, skip to the question for NO respondents.

****

14. Do you use manuals or other items of documentation for the models you are involved with? YES NO

YES respondents:

a. How useful are the manuals or other documentation to you?________________

____

b. What difficulty do you experience in using the manuals or other documentation?____

____

NO respondents:

a. Why do you not use the documentation?________________________________

____

15. If you have a problem or need information about a model, which organizations do you talk to:

****

INTERVIEWER: Be sure the following points are covered:

a) Model name
b) Organization providing the support
b) Type of support you request
c) How the support is made available
d) User satisfaction with the support on the following points: correctness of answer, promptness in returning calls, timeliness of the answer, hours when availabile, any difficulty in understanding, and promptness in following up (documentation, software corrections, letters, etc.).

The following abbreviations are used in the chart:

Type of support:	How support is make available:
C = Choosing a model to use	
D = Supplies data	T = Telephone
S = Software problems	S = Your site
R = Interpreting results	O = Other
P = Programming questions	

****

TYPE OF SUPPORT ORGANIZATION: ________________________ HOW AVAILABLE

____

C	D	S	R	P	MODEL NAMES	T	S	O
0	0	0	0	0	____________________	0	0	0
0	0	0	0	0	____________________	0	0	0
0	0	0	0	0	____________________	0	0	0

How satisfied are you with the support: ________________________

____

____

TYPE OF SUPPORT ORGANIZATION: ________________________ HOW AVAILABLE

____

C	D	S	R	P	MODEL NAMES	T	S	O
0	0	0	0	0	____________________	0	0	0
0	0	0	0	0	____________________	0	0	0
0	0	0	0	0	____________________	0	0	0

How satisfied are you with the support: ________________________

____

____

TYPE OF SUPPORT	ORGANIZATION: ____________________	HOW AVAILABLE
C D S R P	____________________	T S O
	MODEL NAMES	
0 0 0 0	____________________	0 0 0
0 0 0 0 0	____________________	0 0 0
0 0 0 0 0	____________________	0 0 0

How satisfied are you with the support: ______________________________

____

____

16. Do you give support to AQSM users? YES NO

IF YES:

TYPE OF SUPPORT	TO WHOM: ____________________	HOW AVAILABLE
C D S R P	____________________	T S O
	MODEL NAMES	
0 0 0 0 0	____________________	0 0 0
0 0 0 0 0	____________________	0 0 0
0 0 0 0 0	____________________	0 0 0

What are the most common problems or questions: ______________________________

____

____

____

____

17. What kind(s) of computer hardware are available to your organization for AQSM?

****

INTERVIEWER: Be sure the following points are covered:

a) equipment available at the site and any equipment you use offsite (e.g., through telecommunications)

b) If they use that equipment for AQSMs

c) The manufacturer and model for the equipment. If the equipment is located elsewhere and they don't know the manufacturer, put the organization where the equipment is located.

****

AVAILABLE				
ONSITE	OFFSITE	HARDWARE	MANUFACTURER & MODEL	YOU USE FOR AQSMs
☐	☐	Mainframe computer	____________________	YES NO
☐	☐	Mini-computer	____________________	YES NO
☐	☐	Microcomputer	____________________	YES NO
☐	☐	CRT Terminals	____________________	YES NO
☐	☐	Printers	____________________	YES NO
☐	☐	Graphics plotters	____________________	YES NO
☐	☐	Telecommunications	____________________	YES NO_

____

____

____

____

____

18. Do you pay for your present hardware use?________________

If so, how much?____

19. If UNAMAP models were available on another computer for no cost, would you object to additional/new hardware you might have to learn to use? Yes No

____

____

20. How do you assess your ability to get your job done with the current models and computer systems?____

____

____

21. We will suggest a number of possible problem areas. If these seem to characterize your involvement with UNAMAP, briefly describe how:

Buying/locating AQSMs and their updates:____

____

____

____

____

Choosing a model and/or subroutine for a project:

Documentation for the model:

Accuracy of model:

Data collection:

Data/Parameters input:

Hardware problems (access, compatibility,reliability,etc):.

Output format:

Usability of output:

Lack of software support:

Organizational snafus (list the organizations and the problems):

Lack of standards:

Excess costs:

Other:

22. For those problem areas you mentioned, what would remedy your biggest headaches in those areas?

23. Can you estimate the value of the benefits that would be achieved by your suggested changes?

24. How would your effectiveness improve?

25. Why might your suggestions not be implemented?

26. How do the regulatory requirements affect your involvement with UNAMAP and other models?

27. What changes in regulations would have an effect on your involvement with UNAMAP and other models?

28. Are you aware of significant coming changes in AQSM systems or requirements (regulations, AQSM trends, computer/graphics technology, other)?

29.Do you have personal observations about the job, systems, or the organization you feel would be useful to the UNAMAP evaluation?

Appendix B: Questionnaire

QUESTIONNAIRE INSTRUCTIONS

WHAT: This questionnaire is part of an evaluation of the UNAMAP models undertaken by Battelle on behalf of the U.S. EPA. The objective of the survey is to discover how extensively various models and subroutines are being used, the types of computers utilized, and any perceived needs which are not being met by EPA's UNAMAP models. We are interested in the capabilities and advantages of non-EPA models as well.

WHO: The questionnaire has been sent to a large number of organizations, including state air pollution control agencies, federal agencies, contractors, consultants, and industrial groups. You have been selected either because you have purchased UNAMAP or because your organization is known to be a part of the air quality modeling community. Your involvement is important to shape improvements in the UNAMAP models.

HOW: Please answer as many of the questions as possible. Although most of the questions are multiple choice, some will ask you to "briefly describe" some aspect of your involvement with models. These answers increase the quality of the information because they reflect your specific situation. Please use the margins or back of pages if there is too little space for your answer. Since the questionnaire will be going to many types of users of UNAMAP, the exact wording may not always be applicable to you. In those cases, answer the questions in a way which best expresses your involvement with air quality models. A completed sample questionnaire has been included to help you.

WHY AND WHEN: The questionnaire is intended to take a minimal amount of your time. Please complete it promptly and return the questionnaire in the postage-paid envelope included. We would like to have the questionnaire returned by February 20, 1987. It must be returned by February 28, 1987 to be included in the survey. All respondents will receive a copy of the survey results. If your name is not on the label below or if the address is incorrect, please enter the correct information in the space provided:

Name: ____________________

Address: ____________________

____

____

This questionnaire has been submitted for approval to the Office of Management and Budget (OMB) under the Paperwork Reduction Act of 1980, 44 U.S.C. 3501 et seq.

UNAMAP QUESTIONNAIRE

1. Circle the term below which best describes the nature of your current work with UNAMAP or other models:

   User
   Data provider
   Other____________________
   Developer
   Remarketer
   Software support
   Validator
   None

2. If you worked with UNAMAP or other models in a previous job, please circle all of the terms below which apply to that job:

   User
   Data provider
   Other____________________
   Developer
   Remarketer
   Software support
   Validator

   Organization________________________ Approx. Dates______________

3. Check the time period which covers your involvement with air quality models:
   ☐ 1-4 years ☐ 5-10 years ☐ 10 years or more

****
****

4. The following section asks for information about the air quality simulation models with which you currently work. The models you use most should be described first. NOTE: Separate answer areas are provided for UNAMAP and non-UNAMAP models. UNAMAP models are on pages 2 and 3. Other models begin on page 4.

   a) Check the box which describes how long you've used the model;

   b) Fill in the blank with the number of times per week, month, or year that you use the model;

   c) Please use the back of this page to describe more than four models.

USED HOW LONG?	UNAMAP MODEL	# TIMES YOU USE MODEL
____________		
1-4 years	MODEL NAME:____________________	____ per week
____________	____________________________	
5-10 years	VERSION #:____________________	____ per month
____________	How did you obtain/access the model:____	
10 years or more	____________________________	____ per year

Briefly describe any modifications you've made to the model:____________________
____
____

USED HOW LONG?	UNAMAP MODEL	# TIMES YOU USE MODEL
____________		
1-4 years	MODEL NAME: ____________	____ per week
____________	____________	
5-10 years	VERSION #: ____________	____ per month
____________	How did you obtain/access the model?____	
10 years or more	____________	____ per year

Briefly describe any modifications you've made to the model: ____________

____

____

USED HOW LONG?	UNAMAP MODEL	# TIMES YOU USE MODEL
____________		
1-4 years	MODEL NAME: ____________	____ per week
____________	____________	
5-10 years	VERSION #: ____________	____ per month
____________	How did you obtain/access the model?____	
10 years or more	____________	____ per year

Briefly describe any modifications you've made to the model: ____________

____

____

USED HOW LONG?	UNAMAP MODEL	# TIMES YOU USE MODEL
____________		
1-4 years	MODEL NAME: ____________	____ per week
____________	____________	
5-10 years	VERSION #: ____________	____ per month
____________	How did you obtain/access the model?____	
10 years or more	____________	____ per year

Briefly describe any modifications you've made to the model: ____________

____

____

5. Why did you choose to use the particular UNAMAP model(s) you described above?

____

____

____

____

****

USED HOW LONG?	NON-UNAMAP MODEL	# TIMES YOU USE MODEL
____________ 1-4 years	MODEL NAME: ____________	____ per week
____________ 5-10 years	____________ VERSION #: ____________	____ per month
____________ 10 years or more	How did you obtain/access the model? ____ ____________	____ per year
	Have you modified the model? Yes No	

Main purpose of the model (e.g., predicts CO concentrations): ____________

____

Who developed the model: ____________

Briefly describe any advantages this model has over UNAMAP: ____________

____

____

USED HOW LONG?	NON-UNAMAP MODEL	# TIMES YOU USE MODEL
____________ 1-4 years	MODEL NAME: ____________	____ per week
____________ 5-10 years	____________ VERSION #: ____________	____ per month
____________ 10 years or more	How did you obtain/access the model? ____ ____________	____ per year
	Have you modified the model? Yes No	

Main purpose of the model (e.g., predicts CO concentrations): ____________

____

Who developed the model: ____________

Briefly describe any advantages this model has over UNAMAP: ____________

____

____

USED HOW LONG?	NON-UNAMAP MODEL	# TIMES YOU USE MODEL
______ 1-4 years ______	MODEL NAME: ______	____ per week
______ 5-10 years ______	VERSION #: ______	____ per month
______ 10 years or more	How did you obtain/access the model? ______	____ per year
	Have you modified the model? Yes No	

Main purpose of the model (e.g., predicts CO concentrations): ______

Who developed the model: ______

Briefly describe any advantages this model has over UNAMAP: ______

6. Why did you choose to use the particular (non-UNAMAP) model(s) you specified above? ______

****
****

7. Draw a circle around the number on the scale below to indicate the importance of UNAMAP or other AQSMs to your job. The farther to the right the mark, the more important they are:

1	2	3	4	5 .	6	7	8	9	10
couldn't care less				mid point			no job without them		

8. How would you do your job without UNAMAP or other models?

9. Use the chart below to indicate how you learned to use the models with which you are involved:

a) Give the model name

b) Circle the abbreviation for the training methods by which you learned the model. The abbreviations are:

T = Training course, seminar, workshop
U = University course while pursuing degree
S = Self-taught
O = One-on-one training by co-worker

c) Rank the models on the difficulty you experienced in learning them (i.e., put a "1" by the model easiest to learn, a "2" for the next easiest, etc.):

MODEL	TRAINING METHOD	DIFFICULTY IN LEARNING
	T U S O	
	T U S O	
	T U S O	
	T U S O	
	T U S O	
	T U S O	
	T U S O	
	T U S O	
	T U S O	
	T U S O	
	T U S O	

If you use manuals or other documentation for the models, circle the number on the scale which best describes your response to the following two questions:

10. Are the manuals or other documentation easy to understand and use?

0 1 2 3 4 5 6 7 8 9 10
extremely hard very easy

11. How essential are the manuals or other documentation to your work with the models?

0 1 2 3 4 5 6 7 8 9 10
not at all totally

12. Specify below the organizations from which you request support on the models you work with:

a) List the models you ask that organization about

b) Circle the letter(s) to specify the type of support you request

c) Circle the letters(s) to specify how the support is made available.

d) Rate your satisfaction with the support on the following points: correctness of answer, promptness in returning calls, timeliness of the answer, and follow-up (documentation, software corrections, letters, etc.). Specify your level of satisfaction on each point by using a scale where 0 = not satisfied and 10 = completely satisfied.

The following abbreviations are used in the chart:

Type of support:
C = Choosing a model to use
D = Supplies data
S = Software problems
R = Interpreting results
P = Programming questions

How support is made available:
T = Telephone
S = Your site
O = Other - Specify: ______________
____

TYPE OF SUPPORT ORGANIZATION:__________________________ HOW AVAILABLE
____

TYPE OF SUPPORT	MODEL NAMES	HOW AVAILABLE
C D S R P	______________________	T S O
C D S R P	______________________	T S O
C D S R P	______________________	T S O
C D S R P	______________________	T S O

Satisfaction: Correctness____ Timeliness____ Return calls____ Followups____

TYPE OF SUPPORT ORGANIZATION:__________________________ HOW AVAILABLE
____

TYPE OF SUPPORT	MODEL NAMES	HOW AVAILABLE
C D S R P	______________________	T S O
C D S R P	______________________	T S O
C D S R P	______________________	T S O
C D S R P	______________________	T S O

Satisfaction: Correctness____ Timeliness____ Return calls____ Followups____

TYPE OF SUPPORT	ORGANIZATION: ____________________ ____________________ MODEL NAMES	HOW AVAILABLE
C D S R P	____________________	T S O
C D S R P	____________________	T S O
C D S R P	____________________	T S O
C D S R P	____________________	T S O

Satisfaction: Correctness____ Timeliness____ Return calls____ Followups____

13. Use the chart below to specify the kinds of computer hardware that are available in your organization for AQSM:

   a) Put a check in the box(es) to show where the equipment available (e.g., at your site or through telecommunications)

   b) Circle "YES" or "NO" on the right to describe your use of that equipment for AQSMs

   c) Give the manufacturer and model for the equipment. If the equipment is located elsewhere and you don't know the manufacturer, name the organization and location where the equipment is located.

AVAILABLE ONSITE	 OFFSITE	HARDWARE	MANUFACTURER & MODEL	YOU USE FOR AQSMs
☐	☐	Mainframe computer	____________________	YES NO
☐	☐	Mini-computer	____________________	YES NO
☐	☐	Microcomputer	____________________	YES NO
☐	☐	CRT Terminals	____________________	YES NO
☐	☐	Printers	____________________	YES NO
☐	☐	Graphics plotters	____________________	YES NO
☐	☐	Telecommunications	____________________	YES NO

14. Rate your preference of the sources of UNAMAP models which are listed below. 1 = most preferred, and 4 = least preferred

	Rating
1. Mainframe computer (not UNIVAC) at RTP	____
2. Tape from NTIS	____
3. PC-compatible diskettes from NTIS	____
4. Other ____________________	____

15. Below we list a number of possible problem areas with AQSMs. If any of these problems seem to characterize your involvement with UNAMAP or other other models, rate them using the following scale:

0 1 2 3 4 5 6 7 8 9 10

not a problem severe problem

PROBLEM:	RATING:	PROBLEM:	RATING:
1. Choosing a model	______	7. Data input	______
2. Accuracy of model	______	8. Hardware compatibility	______
3. Buying/accessing the model	______	9. Hardware access	______
4. Documentation for the model	______	10. Unreliable hardware	______
5. Support for the model	______	11. Response time	______
6. Data collection	______	12. Other______________	______

16. For the four most significant problems which you identified, briefly describe what would remedy your biggest headaches. Use the following scale to estimate the value of the suggested change and how the change would improve your effectiveness:

0 1 2 3 4 5 6 7 8 9 10

only a little very much

Problem
No. ______
Suggestion:____

____

____

____

Rate the suggestion as to its impact on your effectiveness____

Problem
No. ______
Suggestion:____

____

____

____

Rate the suggestion as to its impact on your effectiveness____

Problem
No. ______
Suggestion:____

____

____

____

Rate the suggestion as to its impact on your effectiveness____

Problem
No. ______
Suggestion:____

____

____

____

Rate the suggestion as to its impact on your effectiveness____

17. On the following scale, circle the number which best characterizes the impact of the "EPA Guidelines on Air Quality Models" (EPA-450/2-87-027R) on your involvement with UNAMAP and other models:

____

0 1 2 3 4 5 6 7 8 9 10

no impact major impact

18. Briefly describe any changes in air quality regulations which would increase or decrease your involvement with UNAMAP and other models. Also, describe any changes which would improve the quality of model data in EIA's.

____

____

____

____

____

____

____

19. Are you aware of significant coming changes in modeling technology or systems (AQSM trends, computer/graphics technology, other) which will have an impact on your work with air quality models?

____

____

____

____

____

____

20. Do you have personal observations about the job, systems, or the organization you feel would be useful to the UNAMAP evaluation?

EVALUATION AND ASSESSMENT OF UNAMAP

PART IV: IMPLEMENTATION PLAN

February 1988

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EVALUATION AND ASSESSMENT OF UNAMAP
PART IV: IMPLEMENTATION PLAN

1.0 INTRODUCTION

The User's Network for Applied Modeling of Air Pollution (UNAMAP) is a software library of air quality simulation models provided by the Environmental Operations Branch (EOB) of EPA's Atmospheric Science Research Laboratory (ASRL). The Evaluation and Assessment of UNAMAP project was designed to facilitate EOB's ongoing efforts to improve the utility and availability of UNAMAP to the public. The project was divided into four major parts, of which this report is the last.

The purpose of this report is to describe a plan for implementing a series of recommended improvements to the UNAMAP program. The plan consists of a definition of strategy consistent with EPA's objectives for UNAMAP, and the schedule and budget to implement the specific recommendations.

The improvements were derived during the course of the investigation, and were based on two major sets of requirements. Technology requirements determine what computer, data, and modeling technology are available to UNAMAP users now and in the near future. User requirements determine what areas of UNAMAP utilization are most difficult and determines where improvement would be most beneficial. Each recommendation has been formulated both to take advantage of the current technological environment and to help meet expressed and implied user requirements.

Because the recommendations are dependent on previous phases of the project, Section 2 of this report provides a summary of the information collected in the earlier portions of the evaluation effort. Each of the following areas will be summarized: (1) assessment of the technological environment, (2) data collection and analysis to determine user requirements, and (3) the major problem areas where user requirements are not being met.

The UNAMAP program has great visibility and impact on the public, including industry, state air pollution control agencies, and community groups. To take advantage of this visibility, UNAMAP needs to provide a centralized modeling service of high quality. The recommended improvements, when taken as a whole, will allow UNAMAP to achieve the following goals:

- To continue as the public source of newly developed and refined air quality models.
- To distribute models which are easily executed on a variety of commonly-used computers of all sizes.
- To provide a wide set of models which are relatively easy to execute, even for the novice or occasional user.
- To offer modelers a central source of technical information, meteorological data, and user support.

To attain these goals, a long-range strategy and milestones are required. Therefore, the first part of the implementation plan is a strategic framework. This will serve as a guideline for the assignment of priorities to the recommendations consistent with the long-term objectives of the UNAMAP program. The strategy is designed to strike a balance between the two objectives of UNAMAP: advancement of research in dispersion modeling, and the effective transfer of modeling technology to the public. This strategic framework is presented in Section 3 of the report.

The strategy will be executed through a set of specific improvements. A description of the tasks and estimated costs to implement the recommended improvements will comprise the majority of this report. Battelle is making ten specific recommendations for improvement to UNAMAP. They are the following:

- Establish an electronic bulletin board on a multi-user computer system.
- Provide a set of end-user documentation for all UNAMAP models.
- Provide models which execute on IBM mainframes, DEC VAX, and IBM PCs.
- Improve the accuracy of models.
- Develop consistent user-friendly interfaces for all models.
- Consolidate all support for all UNAMAP models.

- Establish a meteorological data clearinghouse.
- Include more special purpose models in UNAMAP.
- Support the collection and use of additional and more accurate meteorological data.
- Support the electronic distribution of UNAMAP documentation and updates.

Section 4 of the report summarizes each recommendation, and discusses implementation tasks and estimated costs.

Based on its contribution to the strategic framework, each improvement can be assigned a priority and a completion time estimate. These two factors are used to generate an implementation schedule. The schedule is presented in Section 5.

2.0 PROJECT BACKGROUND

The conclusions and recommendations described in this report are based on research and analysis which were performed in three phases. The first was a technology assessment to determine technology available to UNAMAP. The second was data collection (by interview and questionnaire) and analysis. The third was the derivation of recommendations. These three phases are summarized in this section.

2.1 Technology Assessment Overview

All products follow a pattern of growth which involves changes to the product, the users, and the market. UNAMAP has followed such a growth pattern. The Technology Assessment Report evaluates the technological environment in which UNAMAP exists today and that in which it will function most effectively in the future. The information was used in subsequent stages of the project to provide evaluation criteria for system alternatives and final recommendations.

The technology assessment found that all components of modeling technology have changed dramatically since the development of the first computerized air quality models in the 1960s. The technology is continuing to change at a fast pace. The report covers three distinct phases in air quality model development: (1) the technology as utilized by UNAMAP Version 6; (2) the technologies used by models currently under development as well as adaptations made to UNAMAP to utilize current technology; (3) the technological requirements for future models to solve current problems.

In Version 6, the technology applied to modeling has progressed, while that of the computer systems used to run them has not. The UNAMAP models have become more sophisticated and consistent, while adaptations and processors have improved their usability. The UNIVAC 1100 utilized to support UNAMAP, however, represents no advances since UNAMAP was begun in 1973.

New modeling developments have grown from the modeling community's attempts to deal with today's air quality modeling applications. Model developers are creating models for more challenging environmental problems. UNAMAP users have adapted the models to respond to situations that are different or more complex than those for which the software was designed. Consultants and third-party vendors have contributed more sophisticated data collection and input methods and have facilitated the use of new computer technology.

Modeling software must advance to meet both application and user needs. Modeling has become a successful and important tool in protecting the environment. Because of this success, models are needed for even more complex, real-world situations which need representation. Large, complex regional models are needed by county, regional, and state agencies to study dispersion and transport of pollutants over larger distances. More realistic complex terrain models are needed to represent geographical areas where terrain is a factor.

Users need software which not only fits the application, but is also easier to use. In judging ease of use, the user-friendly, microcomputer products available for other applications will be used as criteria against which the UNAMAP software will be judged.

The data used by the models will continue to be provided by the National Weather Service (NWS) or collected at the site in question. Therefore more consistency of data input and output among the models will be needed to facilitate the novice or infrequent user.

Computer technology will continue its trend toward distributed processing with microcomputers used for an increasing amount of modeling activity, including graphics output. User expectations will also require that data gathering and file transfer technologies in UNAMAP match those available in other application areas.

The typical model user has changed since the advent of UNAMAP. Today, a user may not be a "modeling expert". He may use the models only a few times a year or lack the computer expertise to use mainframe versions easily. Services such as modeling consultants and developers of menu-based microcomputer versions have grown to meet the needs of today's user.

2.2 Data Collection and Analysis Techniques Overview

A major portion of the Evaluation and Assessment of UNAMAP project was the collection of data from UNAMAP users and other members of the dispersion modeling community. The data helped define who uses UNAMAP and how the models are used. The data also identified the areas of the modeling process which users felt should be improved.

There were two parts to the data collection activity: personal interviews and mailed questionnaires. In-depth interviews were conducted with 22 representatives of the following organizations:

- EPA (ASRL and OAQPS)
- EPA Regional Meteorologists
- State air quality agencies
- Local or county air quality agencies
- Private industries (as users of the models)
- Educational institutions
- Modeling consultants
- Modeling software marketers

The interviews provided an overview of the UNAMAP system as well as information on the modeling process. The data from the interviews were used to design a questionnaire which was mailed to a larger segment of the UNAMAP community (256 organizations).

Usable data were returned in 112 questionnaires. These questionnaires were analyzed, and certain types of data were extracted including a user profile, which models are used, and problems encountered in the modeling process. A typical UNAMAP user:

- Belongs to one of four major industry groups: consultant, state government, private industry, or local government;
- Classifies himself as a user of the models;
- Has an experience level which varies by industry group.

The largest portion of the questionnaire dealt with the problems perceived by the users and their suggestions for improvement. Twelve potential problem areas were identified by Battelle project team members based on conversations with EPA. Questionnaire respondents were asked to rank the problem areas as to the severity of the problem. User responses were grouped into low, medium, and high categories. Problem areas scored as medium or high on the severity scale by all major user groups were further analyzed. User suggestions to correct these problems were categorized, and a percentage of suggestions in each category was computed.

Alternatives were generated from the suggestions and from the experience of the Battelle staff in solving similar problems. Evaluation criteria and constraints were identified, and used to determine the strengths and weaknesses of the alternatives.

The suggestions and alternatives were evaluated using the technological context described in the Technology Assessment and Battelle's previous professional experience. Through the evaluation process, Battelle developed a list of recommendations. The recommendations were formulated to address multiple problem areas wherever practical, and to utilize technology which is available to the UNAMAP support staff and model users. The implementation of these recommendations comprise the bulk of this report (Section 4).

2.3 Problem Area Overview

Six out of the original twelve potential problem areas were rated as major problems by the users. These are the problems which our recommendations attempt to rectify. They are discussed in this section. Figure 1 shows the areas specified as major problems as well as the potential problems not considered significant by most users.

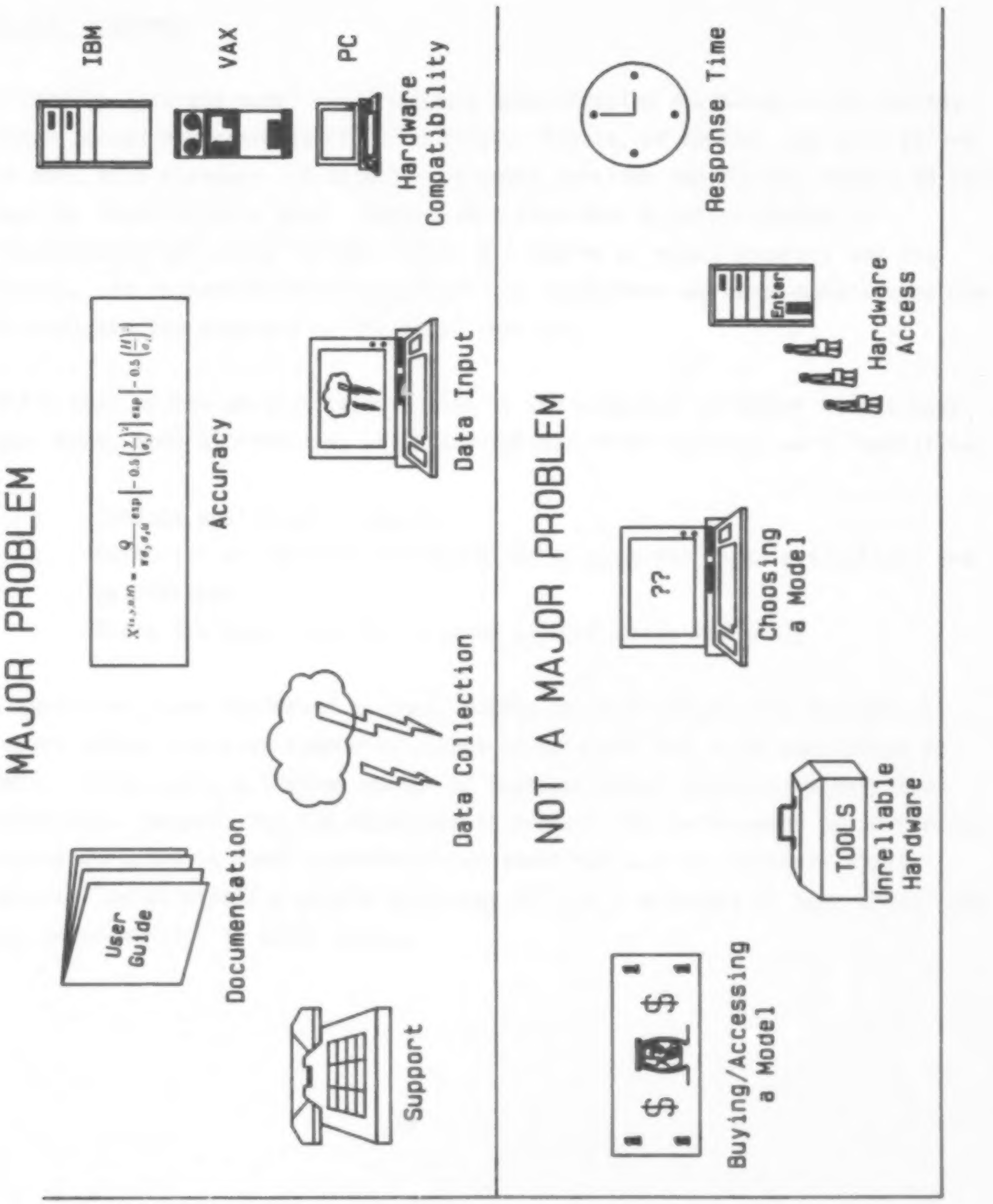

Figure 1. Problem Areas Ratings of Seriousness

2.3.1 Accuracy

A totally accurate model would produce concentration estimates which exactly match actual measurements of air quality. Models, of course, can only strive to meet this standard. A majority of users consider the current models to fall too far short of this goal. Model users also want a better method for interpreting and using information on the degree of model accuracy and its limits. It is particularly important that management decision-makers know how to evaluate the accuracy of the model results.

While most of the obvious improvements to the accuracy of UNAMAP models have been made, some alternatives which can improve model accuracy were identified:

- Conduct additional research
- Establish an improved dissemination process for those evaluations and validations
- State the model results in terms of confidence intervals

Alternatives were evaluated on cost, degree of improvement, and breadth of impact within the user community. Some constraints had to be considered as well. First, only a limited number of thorough model evaluations have been conducted. Second, the EPA objective to protect the environment by preferring over-prediction to under-prediction can sometimes act to constrain model accuracy by eliminating models which may be highly accurate in some cases, but may under-predict in other cases.

2.3.2 Documentation

The data indicated that documentation in the form of user's guides and system documentation is very important to the modelers. Many users stated that the manuals were inconsistent, not oriented for the novice or infrequent user, and changes to the manuals did not get to those who needed them.

There are two alternatives to improve ease of use. First is a separate set of user manuals for the novice or infrequent user with a "cookbook" approach and more examples. Second is to rewrite the existing manuals adding new ease-of-use features and improving the consistency. The distribution of documentation would be quickened and simplified by use of electronic media.

The documentation alternatives must be considered in relation to several constraints.

- Preparing documentation is time-consuming and expensive;
- Existing distribution channels are not conducive to frequent updates;
- EOB does not have the personnel resources available to assume distribution responsibilities.

The proliferation of user-friendly, microcomputer products for other applications has led to a generally increased level of expectation in terms of documentation clarity and ease of use. The UNAMAP system must recognize these expectations and employ current documentation techniques and standards.

2.3.3 Support

User support consists of information and assistance provided to answer questions and give guidance as to the proper application and successful execution of the UNAMAP models. Currently UNAMAP support service responsibilities are divided. EOB helps users with the modeling software while the Office of Air Quality Policy and Standards (OAQPS) answers questions on regulatory issues.

Overall, support was rated as at least a medium-level problem by all user groups. The quality of support was not the issue; users indicated that UNAMAP support is too fragmented and decentralized.

There are three alternatives to standardize UNAMAP support:

- Support activities could be integrated into the Regional Offices;
- Centralized support could be provided by a Modeling Support Branch within EPA;
- Standardized model components and a help facility could be developed to reduce support requirements.

All support alternatives must be judged on the level of service given to users and cost effectiveness. Support alternatives should also be evaluated in the context of other planned improvements such as documentation changes and user interfaces. The primary constraint on support, of course, is staff resources.

2.3.4 Data Collection

Collection of meteorological data is a significant part of air quality modeling. There are two sources of meteorological data: data from a National Weather Service (NWS) installation near the site or data collected at the site itself. Users complain that there is no comprehensive source of information on what data are available, and how to get it.

One alternative is a data clearinghouse. Such a clearinghouse could offer a variety of services from a simple newsletter to an electronic bulletin board. The services to be provided and the medium of communication may be limited by the initial effort required. The volume of data available to the clearinghouse may constrain its services or medium.

2.3.5. Data Input

After data has been collected, the data input phase is required to resolve any data problems, format the data, and enter items such as receptor locations and other terrain data. Data input is often a manual function although preprocessor programs can correct several types of data problems.

UNAMAP users want data input to be made easier. Novice or infrequent users, especially, must expend a great deal of effort in determining how to enter data for each specific model. There are three alternative approaches: change the data, change the models, or provide an interface between the data and the models.

The main constraint for data input alternatives is the level of effort required to implement the various approaches. A full-screen, interface program, for example, will require a separate version for each type of terminal protocol to be supported.

2.3.6 Hardware Compatibility

There are many types of computer hardware used for modeling by the UNAMAP community, but one brand (UNIVAC) has been the "standard". Users of other hardware convert the software or find a company selling the version they need. Although UNIVAC has been the standard version of the models since they began, EPA's National Computer Center (NCC) is converting all UNIVAC operations to IBM. Future models will be supported on hardware other than the UNIVAC. Whatever the standard version, users of other hardware may be required to convert the models. The ideal hardware compatibility solution would provide a version of the UNAMAP models for every type of hardware used by the modeling community. This ideal cannot be met with current resources.

Alternative approaches to increase hardware compatibility fall into two categories: support multiple hardware or make the conversion process easier. Resources are major constraints on hardware compatibility alternatives. Choice among these alternatives must be based on cost effectiveness and usefulness to the modeling community. Support of multiple types of hardware would benefit the users, but would be extremely costly in terms of resources. Easing the conversion process would also require a major effort.

3.0 RECOMMENDED IMPLEMENTATION APPROACH

UNAMAP is the primary mechanism used to promote two of the ASRL Meteorology Division's major objectives: research in dispersion modeling and transfer of the technology to the public. Research keeps the field of dispersion modeling technically viable and publicly credible. Technology transfer is the process by which the results of research are made available for use by the public. Because these two objectives are interdependent, any strategy for improving UNAMAP must consider both. To restate the conclusions of the Technology Assessment (Section 2.1), changes have occurred in the UNAMAP user community, and in the UNAMAP software library itself since UNAMAP was begun. The questionnaire results indicate that these changes have resulted in a reduced effectiveness of the UNAMAP program in meeting its two objectives.

3.1 Changes in the UNAMAP Program

UNAMAP began as a centralized, timeshared system used by a relatively small group of experienced modelers whose needs were, for the most part, being met. These modelers were users, developers, and evaluators. Their intimate knowledge of the models, as well as their involvement in multiple aspects of the dispersion modeling program, limited the need for support and ease-of-use features. The UNAMAP program of 1987 is different in two significant respects.

The most significant change to the UNAMAP program since it was established in 1973 has been a growth in the number of users and in the purposes for which they use the models. This trend has affected UNAMAP in several ways. First, users are not as likely to be intimately involved in dispersion technology or in model development as were users in the past. Novices and infrequent users rely on experienced personnel to help them. As a result, support needs have increased. Second, at the same time support needs have increased, the growing size of the community has reduced communication between users and model developers. This has placed an additional burden on EOB to provide all support. Third, the increased number of users has resulted in models being converted to and executed on a wide variety of computers. This has greatly increased the complexity of providing usable code, data, and documentation.

The second significant change to UNAMAP is the inclusion of an increased number of models produced by many different developers. In 1978, Version 3 of the UNAMAP library consisted of 11 models, all directly supported by EOB. Version 6, released in 1986, contains 25 models, developed by a variety of consultants, industry, and EPA contracts. Besides the increase in the number of models, users find it difficult to adjust to the differences between models. These differences can be significant because models are developed by individuals or institutions to meet specific needs. As a result, consistency and standardization among them has not been a goal.

These two changes have generated a requirement for the UNAMAP program to become more user-oriented. This implies that (1) the novice user must get more consideration, and (2) there must be greater emphasis on uniformity of operation for the models.

3.2 Research vs. Technology Transfer

The new UNAMAP must emphasize both practical and research concerns. As air quality modeling has become an integral part of the regulatory process technology transfer has become more of a challenge. Modelers are under pressure to run the models and produce results to be used for regulatory purposes. For many users, these concerns take priority on a day-to-day basis. On the other hand, there are certain aspects of the models that require serious study. For example, the accuracy of models has not been evaluated for many sets of conditions. Also, the technology utilized in many of the regulatory models is outdated.

There are several possible interpretations of what constitutes technology transfer. A narrow definition implies that the technology can be transferred by transmittal. In such an approach, the technology is made available to the public in more or less the same format as that in which it was developed. Alternatively, a broader definition emphasizes the quality of the transfer with varying levels of information and adaptation of the technology to meet the test of usability. Because of the previous sophistication of its user community, UNAMAP has always leaned toward a fairly narrow definition of technology transfer. To be effective in the future, UNAMAP must meet the needs of a larger, more varied user group.

3.3 Strategic Objectives

Any changes must address the current state of user requirements and the current set of models first. Only from this base can advancements be made. Therefore, approaches discussed in this section will first expand the users' ability to use the models, and then serve to advance the modeling technology being used. The initial changes must allow UNAMAP to evolve to meet the current expectations of the modeling community. When using the regulatory models is less difficult, modelers will be able to turn more of their attention to the research aspects of modeling. As in the early days of UNAMAP, the user community will become more involved in the process of testing and validating new models as part of the research cycle.

The new "Strategic Vision" for UNAMAP, presented here, is also an acceptance of its evolution toward a more distributed system with modelers using a variety of computer hardware to meet different modeling requirements. UNAMAP began as a centralized program, but changed to a distributed environment in response to technological advances in computer systems and the growth of the user community. Instead of being restricted to a timeshared system, modelers now have access to computers at the regional and local level and to microcomputers on their own desks. They run models on whichever computer hardware is most accessible, easy to use, and cost-effective.

There are three objectives which, if achieved, will promote the growth of the new UNAMAP:

1) To continue improving the models in UNAMAP through research
2) To provide a single source of information for modelers
3) To make all UNAMAP models easier to use

These objectives will promote the two functions of EOB: research and technology transfer.

The research objectives of the UNAMAP program must continue. Battelle recommends that the research focus on improving the accuracy of the general purpose models and on the development of new special purpose models. Because of the importance of the model results in the regulatory process, accuracy is an important issue to users and decision-makers. More research will be necessary to improve the accuracy of models being used in the permitting and EIS applications.

New models are also important to the UNAMAP community. Again, largely because of increased use of models for regulatory purposes, models are needed which address new problems and new terrains. UNAMAP, as the largest single source for air quality modeling software, is perceived by the public as the logical origin for all dispersion modeling software.

The UNAMAP program must also take a lead role in providing a centralized information source for all modeling needs. EOB staff members currently supply some support. Users must, however, go elsewhere to order the models, purchase meteorological data, and get certain types of support for some models and applications. Users expect centralized support through UNAMAP and are confused at the actual complexity of the support network.

Battelle's approach recommends that a new dimension be added to the technology transfer by making UNAMAP a central source for all air quality modeling technology. This "one stop shopping" concept should provide modelers with information regarding the following topics:

- Meteorological data
- Technical advice
- Model documentation
- Modeling software updates
- Support services

The new UNAMAP will provide this technology transfer by using electronic communications for improved transfer of model changes, documentation updates and meteorological data to the modeling public. This capability will also serve to transfer technology secondarily by facilitating communication among modelers.

To serve the current modeling community, the models must be made easier to use. Ease of use includes software which can be run on the various types of computer hardware widely used for modeling. It also includes solving such user problems as lack of consistency between models, the need for user interfaces, and improvements in user documentation.

Battelle's strategy for UNAMAP has two thrusts. The initial focus is to make the system easier to use. The goal of this focus is to make the modelers more efficient at performing their regulatory duties. Through increased ease of use, modelers will be able to concentrate on modeling techniques rather than on mechanics. The second stage is predicated on the assumption that once they can execute the models more easily, users will attempt to use the newer models. They will experiment with their data to compare how various models perform in specific instances. This will increase the base of users knowledgeable in the newer models. These users can become the impetus for improved technology in the regulatory portion of the UNAMAP program, and can provide valuable input to the future direction of air quality modeling.

4.0 IMPLEMENTATION OF RECOMMENDATIONS

This section describes the implementation of specific recommended improvements which will promote the increased effectiveness of UNAMAP. The recommendations do not individually correspond to specific problems described in Section 2. Instead, they are designed to support the long-range objectives of the UNAMAP program and remedy the underlying causes of current problems.

Achievement of the strategic objectives will help UNAMAP continue to fulfill its leadership role in air quality modeling.

4.1 Recommendation 1: Establish an Electronic Bulletin Board

Battelle recommends that EPA establish an electronic bulletin board on the Meteorology Division MicroVax computer. This bulletin board system would provide the capability to send messages to a specific person or groups, broadcast messages to all users, and transfer files to and from the system.

The bulletin board would increase the user-oriented aspect of UNAMAP. The initial uses of the bulletin board would be to provide UNAMAP support (answer questions via electronic mail) and to distribute information of value to the UNAMAP community at large. Minor software patches and documentation updates could also be provided over the bulletin board.

Later, the services provided could increase as computer resources and communication lines allow. For example, the system could be expanded to allow distribution of new versions or releases of the models, new manuals, and possibly data.

The bulletin board could also increase use of the research models. Currently, some research models are included on the UNAMAP tape in the hope that modelers will use them and provide input into the testing and validation of these new models. The models, however, go out indiscriminately to all purchasers with little chance for "marketing."

4.1.1 Implementation Tasks

Battelle recommends the following task structure to provide a bulletin board system for UNAMAP users. This workplan is based on Battelle's experience in bulletin board development for another government agency. The plan contains several tasks listed below:

Task 1: Software Evaluation

- Prepare a set of requirements and evaluation criteria to include such functions as: bulletins, private electronic mail, distribution lists, and file transfer.
- Develop a list of available multi-user bulletin board software.
- Determine which of the available systems meets the initial evaluation criteria.
- Set up demonstrations of software chosen for further review.
- Develop a list of in-depth evaluation criteria (for example, ease-of-use, flexibility, growth potential, etc.).
- Evaluate the systems demonstrated.
- Choose the software which fits UNAMAP's needs.

Task 2: Hardware Procurement and Implementation

- Order modems, cables and communication ports for MicroVax.
- Order telephone lines.
- Set up modems.
- Test all equipment together.

Task 3: Implement Software on Meteorology Division MicroVax

- Determine changes which must be made to the basic software.
- Tailor the basic software for EPA (welcome message, bulletin names, etc.).
- Install the software system on the MicroVax.

- Test the system with the hardware.
- Provide system operator training.
- Prepare a means of advertising the bulletin board system to the user community.
- Prepare an end-user tutorial/documentation packet.

4.1.2 Estimated Costs and Time

We have based our cost estimates for a bulletin board system on a similar software system developed by Battelle for DOE. The software provides bulletins, private (encrypted) electronic mail, distribution lists, and file transfer functions.

- Labor (at Contractor rates):

Task 1:	40 hours	
	40 hours x $60 =	$2,400
	Time = 60 calendar days	
Task 2:	20 hours	
	20 hours x $60 =	$1,200
	Time = 60 calendar days	
Task 3:	40 hours	
	40 hours x $60 =	$2,400
	Time = 30 calendar days	
		======
TOTAL	100 hours x $60 =	**$6,000**

- Hardware (list prices):

MicroVax communication ports	$1,520 for 8 (DHV-11)		
	+ 330 installation		= $1,850
Modems (Racal Vadic 2400 PC)	3 x	$ 600 each	= $1,800
Cables	3 x 10		= $ 30
			======
TOTAL			**$3,680**

- Other costs:
  3 telephones lines (GSA Cost)
  Staff time = 12 hours/month

The necessary management time constitutes the system's operating cost. The system manager should be an EOB staff member. Based on the DOE application, we estimate approximately 12 hours per month will be required for file transfer, update of bulletin boards, and message clean-up.

Battelle estimates that it will take 60 calendar days to select software and tailor it to fit EPA's needs. The other major time constraint will be the time required for delivery of the necessary hardware and telephone lines. The MicroVax ports and modems have an estimated arrival time of 30 days after order. EPA experience at RTP indicates that approximately 45 days are needed for telephone line installation. Testing, training, advertising and the tutorial will require about 45 calendar days after the hardware is installed.

4.2 Recommendation 2: Produce, Distribute, and Support a Series of End-User Documentation

Battelle recommends that improved end-user documentation be developed to enhance the user-orientation approach of UNAMAP. The existing documentation is not sufficiently functional to play the important role users expect of it. As the UNAMAP user community continues to expand, the demand for and reliance on high quality documentation will increase, as will the importance of documentation in supporting system acceptance among growing numbers of less technically oriented users.

New documentation should be designed, developed, tested and distributed to end-users. Battelle recommends an initial documentation design concept based on a preliminary reader analysis that will ensure that user requirements are met. Specifically, this design would result in documentation that:

- o Acknowledges and addresses multiple types of users;
- o Is easy to use for various needs of all user types -- specifically for initial learning, routine reference, and additional background;
- o Provides consistency from one model to the next, yet allows for the variation inherent in each model;
- o Exists for all models;
- o Can be prepared and distributed in an efficient manner;
- o Lends itself well to revisions and updates.

The documentation design and organization would be based on a functional or task orientation. The manuals would be written for the non-technical reader, tested by novice users. Since so many users depend on the manuals to learn the models, manuals should include some self-paced teaching exercises. Manuals for each Appendix A and B model would be produced, including Complex I.

Documentation can be provided using various media and through different channels. The documentation could be produced in a paper version and distributed through the EPA Regional Meteorologists. This alternative addresses some of the current problems identified by users. The closer contact between the regions and users would provide the documentation and revisions in a timely manner to the actual users rather than to the name on the purchase order.

A second alternative would be to produce the user manuals in electronic format and distribute them through the electronic bulletin board. The distribution of the documentation and updates would be much faster and paper output could be controlled by the user. Section 4.10 discusses this alternative in more detail. An advantage of either alternative over the current system is that revisions could be made to the manuals more easily. The structure recommended for the manuals uses a modular approach which will allow changes to be made in individual sections without affecting the rest of the document.

The recommended organization for the revised documentation takes all these requirements into consideration. The organization separates general overview material, specific functional instructions and procedures, and reference for various types of user needs and interests. The annotated outline included in Appendix A identifies a general plan for the major sections in the proposed revision to UNAMAP documentation.

4.2.1 Implementation Tasks

The implementation tasks are based on Battelle's well tested documentation design and development methodology. The plan includes four tasks: project design and planning, first draft, revised draft, and final copy. The activities involved in the four tasks are listed here, with EPA review cycles indicated.

Task 1: Project Design and Planning

- o Define project scope and limitations (specific goals, schedule, expectations, requirements).
- o Collect resources (existing documentation, related materials, access to software, contact with subject matter experts/experienced users, as required).
- o Learn use of model.
- o Refine initial reader analysis.
- o Develop document design (detailed working outline), to include:
  - introductory and overview paragraphs
  - notes about additional information required from EPA
  - sample page designs
  - binding recommendations.
- o Deliver refined reader analysis and documentation design (working outline) to EPA.
- o Adopt or develop style guide.
- o Secure EPA approval.

Task 2: First Draft

- Building on working outline and incorporating EPA comments, complete first draft, with all sections as complete as possible.
- Test first draft.
- Edit first draft to reflect feedback from testing effort.
- Deliver first draft to EPA.
- Secure EPA approval.

Task 3: Revised Draft

- Incorporate EPA comments on initial draft.
- Do all required revisions and editing.
- Retest revised draft.
- Edit revised draft to reflect feedback from testing effort.
- Deliver revised draft to EPA.
- Secure EPA approval.

Task 4: Final Copy

- Incorporate EPA comments on revised draft.
- Conduct final documentation test.
- Edit to incorporate feedback from final testing effort.
- Print final camera-ready art.
- Conduct final production proofreading.
- Deliver final camera-ready art to EPA.
- Secure EPA approval.

4.2.2 Estimated Costs

For the purposes of estimating the cost of this improvement, UNAMAP models have been grouped into two general categories -- simple and complex.

Simple $17,000 x 15 simple models = $255,000
Complex $34,000 x 9 complex models = $306,000
========
TOTAL = $561,000

The time required to develop the documentation for one simple model is estimated at about 200 hours for one FTE technical writer/documenter, and 66 hours for a modeling systems analyst. For one complex model, the estimate is about 400 hours for one FTE technical writer/documenter and 132 hours for a modeling systems analyst.

Costing Assumptions and Detail

The following assumptions were used to develop the cost/time estimates:

1. The examples we have (CDM for simple, ISC for complex) are typical for each type model.
2. Camera ready art (CRA) and electronic media in EPA-specified formats will be the final product to EPA from the documentation developer.
3. The finished documentation will be used as a paper-based tool, but may be distributed electronically for local printing by users.
4. Existing documentation will be provided by EPA to the documentation developer in paper format only.
5. Technical writers/documenters will have access to software and to subject matter experts and expert users as required.
6. Documentation revision begins after conversion of code to ANSI F77 (Section 4.3) and interfaces (Section 4.4).

Time estimates in days, by task are as follows:

	Simple		Complex	
	Doc. Spec.	Sys.	Doc. Spec.	Sys.
Task 1: Project Design and Planning	30	30	60	60
Task 2: First Draft	90	30	180	60
Task 3: Revised Draft	40	6	80	12
Task 4: Final Copy	40	0	80	0
TOTAL	200	66	400	132

4.3 Recommendation 3: Provide UNAMAP Code, Data, and Documentation for Multiple Computers

Battelle recommends that EPA actively provide UNAMAP software for the following types of computers: IBM mainframes, DEC VAX, and IBM-compatible PCs. These are the computers most frequently used for UNAMAP modeling, according to the Battelle questionnaire responses. This improvement will directly serve the long-range goals of UNAMAP in many ways. It will make the conversion process either vastly easier or totally unnecessary, which will allow new versions of the models to be executed with less expenditure of time and effort, and it will make the non-regulatory models more available.

There are two possible approaches to implement this recommendation. The first is to distribute distinct versions of UNAMAP for each computer type. Users would specify which version they wanted when ordering UNAMAP. The second alternative is to provide "universally executable" (ANSI Standard F77) code and to provide data which can be loaded and accessed in the same way by all three types of computers. Under this approach, UNAMAP documentation would need to contain instructions for loading data and running the models on each type of computer. To support the IBM PC version, a standard compiler should be selected and supported.

Based on our recent analysis of UNAMAP models, Battelle recommends the second approach. In our analysis, we performed experiments with two UNAMAP models, CDM 2.0, and ISCST. These experiments found that only very minor modifications were required to produce code that executed in all three environments. The CDM documentation indicated that the model ran without modification on an IBM mainframe under MVS and Fortran; the JCL for setting up the batch job was included in the documentation as well. An OPEN statement for the punched output file was added for the VAX version and for the PC version. On both VAX VMS F77 and on Microsoft Fortran, we compiled with the compiler set to the ANSI standard version (no extensions). Results from all three computers were identical.

The major effort may be providing input data formats that can be run on all three computers. A standard microcomputer configuration would require an ASCII (not binary), preprocessed, disk-based (not tape) input file. Transfer and execution of input data is on mainframes in this format as well. Currently, mainframe-oriented UNAMAP preprocessors do not provide a disk-based ASCII file. As part of the multiple computer support approach, Battelle recommends that EPA provide, or allow for the use in all models, of preprocessed data in a form that is directly transferable to an ASCII disk file.

4.3.1 Implementation Tasks

Task 1: Modify all models to execute on IBM, VAX and IBM PC

- Obtain models and install on all environments
- Obtain data
- Make known modifications in advance. Test. Make modifications which emerge during testing.

Task 2: Make necessary modifications to data preprocessors and model code for preprocessed ASCII disk file input

- Convert data from binary to ASCII.
- Modify preprocessor to produce ASCII characters to a disk-based file.
- Convert model code to accept ASCII data from a disk-based file. Test.

Task 3: Incorporate machine-specific execution instructions, any remaining machine-specific modifications, and updated data input instructions into documentation.

4.3.2 Estimated Costs and Time

Task 1 and Model portion of Task 2:

- Labor to fix and test
  5 simple models at 8 hours = 40 hours
  (ANSI F77 and IBM version is currently documented - e.g., CDM-2.0)
  40 hours x $60 = $2,400
  10 simple models at 32 hours = 320 hours
  (No ANSI or IBM version currently exists)
  320 hours at $60 = $19,200
  9 complex models at 60 hours = 540 hours
  (older, less structured code, more options, less well-documented - e.g., ISC)
  540 hours x $60 = $32,400
- Computer time: approx. $5,000
- Total cost = $59,000
- Estimated time = 150 calendar days (two persons)

Task 2: Preprocessor part only

- Labor to fix and test
  Two preprocessors at 80 hours = 160 hours
  160 hours at $50 = $8,000
- Estimated time = 30 days (two persons)

Task 3:
This estimate only considers the incremental portion necessary to add these specific portions into the documentation as it is revised in accordance with Section 4.2.

- Labor to update documentation
  24 models at 16 hours = 384 hours
  384 hours at $60 = $23,040

4.4 Recommendation 4: Improve the Accuracy and Technology of Models Included in UNAMAP

Battelle recommends that EPA continue research to improve the predictable capability of dispersion models used by the public. Improving the accuracy of the regulatory models and advancing the modeling technology in UNAMAP are necessary to continue the viability of the program. Although improvements to the accuracy of UNAMAP models will not be cheap or easily accomplished, Battelle recommends that the new UNAMAP include major efforts in this area.

4.4.1 Implementation Tasks

Although specific research activities are best defined by EPA researchers, there are several alternatives available which will address one or more of the accuracy issues raised by users. Each alternative requires different skills and resources to accomplish.

The first alternative is to do what is required to improve the predictive accuracy of UNAMAP models. This would be done in three steps. The first step is to compile known accuracy problems from all sources. The second step is to conduct additional research to correct these problems and improve the models. The research will include more model validation and evaluation activities, within specific situations, for a variety of models. Research will also be done to improve the scientific basis of dispersion modeling. The third step is to have any improvements incorporated into the regulatory process.

A second alternative is to provide the modeling community with information on the accuracy of the models. This would require an improved dissemination process. The information must be presented for two audiences: dispersion modelers and decision makers. Technical discussions of model accuracy can be provided through the bulletin board and included in the user's manual for each model. Non-technical discussions of accuracy should also be provided through the bulletin board.

Advances in modeling technology will occur through the research activities. These advances must, however, go through testing, evaluation, and review processes. Members of the UNAMAP user community must be encouraged to become part of these processes.

A third alternative is to implement several changes in the ways models are developed and tested to facilitate user participation. First, new research models should function with a screen-oriented user interface, such as the one described in Section 4.5. This will expedite their use and acceptance. Second, the bulletin board could be used to recruit persons interested in testing a new model. Currently, new models are put on the UNAMAP tape in the hope that they will be used. The bulletin board could be used to publicize the models. Third, new models could be downloaded via the bulletin board, run by the modeler, and comments returned through electronic mail. This would greatly speed the testing process.

4.4.2 Estimated Costs and Time

The activities described for improving the accuracy and technology of the UNAMAP models are not easily quantifiable either by cost or level of effort. They represent a direction in which to focus research resources and have the greatest possible impact on UNAMAP users. The UNAMAP modeling community considers these activities to be of the utmost importance. Resources need to be dedicated to these activities.

4.5 Recommendation 5: Develop a Consistent Set of User Interfaces

Battelle recommends that screen-oriented software be added to all UNAMAP models. The goal is to make all models in UNAMAP appear as much alike as possible. By easing the data input and model setup burden, this improvement will directly support the objective of making UNAMAP models easier to use. In addition, by providing a similar interface across regulatory and research models, the use of the non-regulatory models will be encouraged.

In general, the interface software would first allow the user to specify execution options, then proceed through the input specifications (based on the options selected), in the same order for all models. For example, after options were specified, the software could display a "source characteristics" data screen such as the one shown in Figure 4-1.

All conversions of units, formatting to the model's requirements, decimal conversions, etc. could be performed by the interface.

Variations would be required in the software to allow for variations in source characterization, such as end points for line sources, and diameters or corners for area sources. The interface software would determine, based on the model and the options selected, which data was required. The interface would ensure that the data was put into the input file in the format needed by the model.

Because screen-oriented software is specific to a given type of terminal, separate versions could be required for each type of hardware (i.e. IBM, VAX, and PC) supported. Alternatives to distinct versions are: (1) to write all screens in ANSI Cobol, which is portable between IBM and VAX, or (2) write the interface to execute on a PC, which transmits the job stream and input file to a VAX or IBM mainframe. Battelle recommends the latter approach. In any case, the effort required to provide interfaces to all models and in all hardware versions is significant.

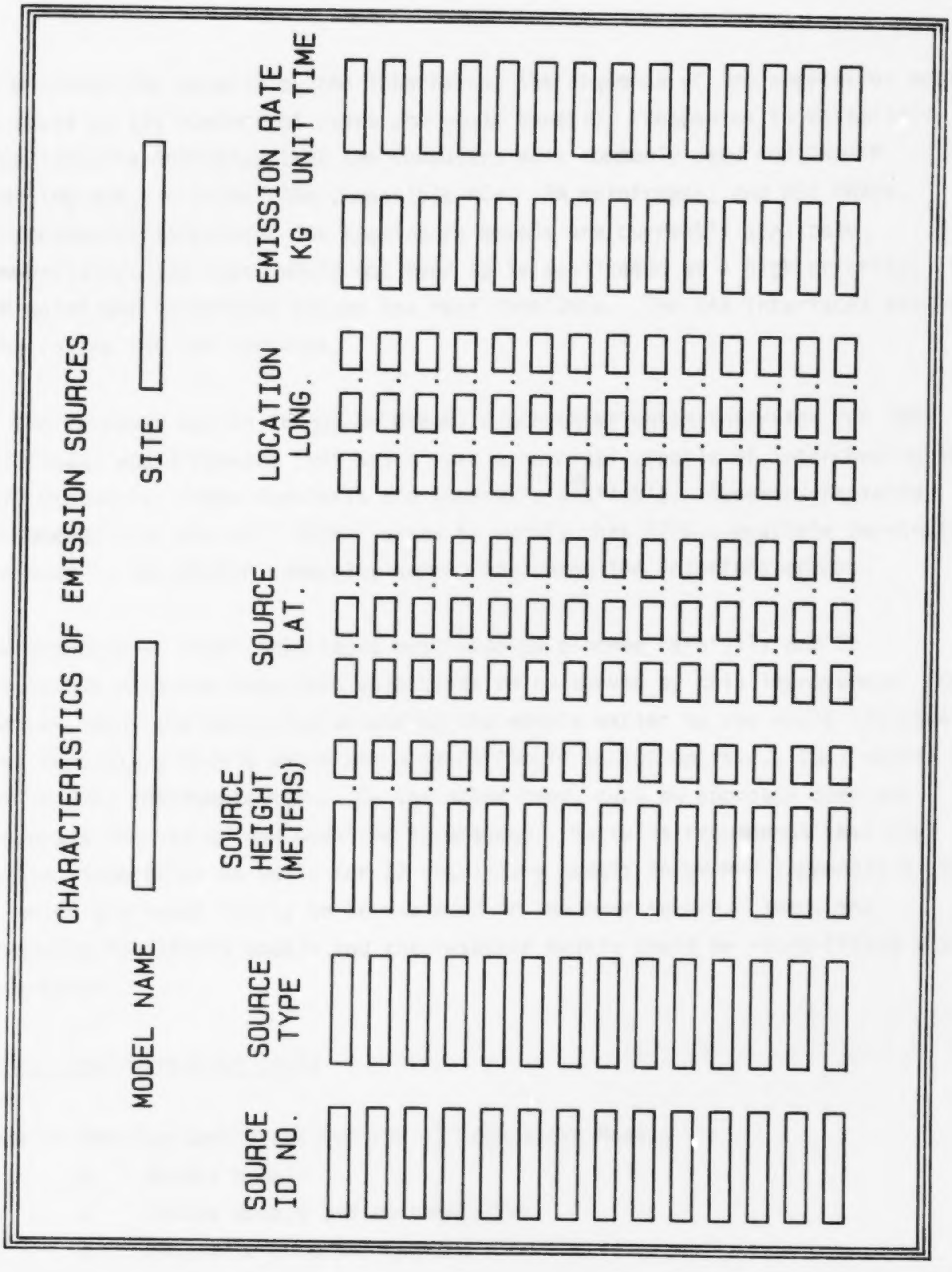
CHARACTERISTICS OF EMISSION SOURCES
MODEL NAME
SITE
SOURCE ID NO.
SOURCE TYPE
SOURCE HEIGHT (METERS)
SOURCE LAT.
LOCATION LONG.
EMISSION RATE KG UNIT TIME

Figure 2. Source Characteristics Data Screen

To maximize the benefit of the interfaces, the sequence of implementation must be based on the numbers of users who would benefit. Responses to Battelle's questionnaire indicated that the computers most commonly used for UNAMAP modeling are, in order, IBM-compatible PCs, IBM mainframes, and DEC VAXes. Microcomputer interfaces for regulatory models are currently available commercially, and thus, would not need to be duplicated as a high priority. IBM mainframe interfaces become the next candidate. The VAX interfaces should then follow the IBM versions.

If the PC-based option is not selected, a screen-oriented interface for IBM mainframes would require that users have a terminal capable of interpreting IBM 3270 protocol. These terminals are generally available. However, Battelle recommends that EPA poll UNAMAP users to verify that 3270-compatible terminals are used in the UNAMAP community before beginning the interface effort.

The sequence of model interfaces must also be planned carefully and in accordance with the long-term objectives to be served by this improvement. On the one hand, the objective of making the models easier to use would indicate that regulatory models which are most difficult to set up (e.g., ISC) should be the initial implementations. On the other hand, such an approach does not encourage the use of new modeling technology. Battelle recommends that the initial interfaces be built for 12 regulatory models in UNAMAP (Appendix A and B) which are least likely to be replaced in the near future. Then, the remaining regulatory models and the research models could be retro-fitted with interfaces.

4.5.1 Implementation Tasks

Task 1: Develop Specifications for 12 Regulatory Models

- Select models
- Review models and documentation
- Determine possible options
- Analyze data input requirements for all option combinations
- Prepare logical flows and screen layouts for each model

Task 2: Develop Interfaces for 12 Regulatory Models

- Write IBM JCL
- Write screen formatting programs
- Write logic to link screens to options
- Test on IBM
- Write VAX "JCL"
- Test on VAX

Task 3: Develop Specifications for Remaining Models

- Review models and documentation
- Determine possible options
- Analyze data input requirements for all option combinations
- Prepare logical flows and screen layouts for each model

Task 4: Develop Interfaces for Remaining Models

- Write IBM JCL
- Write screen formatting programs
- Write logic to link screens to options
- Test on IBM
- Write VAX "JCL"
- Test on VAX

4.5.2 Estimated Costs and Time

These costs are in terms of estimated contract rates for systems analysts and senior programmers. Hourly estimates are given so that EPA can estimate the level of effort to perform the work, regardless of whether or not it is contracted.

Task 1: Labor for specifications for 12 models

- o Six simple models at 20 hours = 120 hours
  120 hours x $60 = $7,200
- o Six complex models at 40 hours = 240 hours
  240 hours x $60 = $14,400
- o Total cost: $21,600
- o Estimated time: 90 calendar days

Task 2: Labor for development of interfaces for 12 models

Obviously, this effort depends on the approach taken: multiple versions, a portable Cobol version, or a PC-based version with VAX and IBM options. The estimates below are for one version, and should be adequate for any of the three approaches.

- o Six simple models at 30 hours = 180 hours
  180 hours x $60 = $10,800
- o Six complex models at 60 hours = 360 hours
  360 hours x $60 = $21,600
- o Total: $32,400
- o Estimated time: 180 calendar days

Task 3: Labor to Develop Specifications for 12 models

- o Nine simple models at 20 hours = 180 hours
  180 hours x $60 = $10,800
- o Three complex models at 40 hours = 120 hours
  120 hours x $60 = $7,200
- o Total cost: $18,000
- o Estimated time: 75 calendar days

Task 4: Labor to Develop Interfaces for 12 Models

- Nine simple models at 30 hours = 270 hours
  270 hours x $60 = $16,200
- Three complex models at 60 hours = 180 hours
  180 hours x $60 = $10,800
- Total cost: $27,000
- Estimated time: 120 calendar days

4.6 Recommendation 6: Provide Centralized Support for All Models

Battelle recommends that a centralized support group be established within EPA. The staff of the "Modeling Support Branch" would have expertise on all the UNAMAP models, a variety of hardware, and would be authorized to convey regulatory requirements within certain conditions. Improved methods of communication between support staff, users, and developers would increase the speed and quality of the support services offered to the modeling community.

It is unlikely that the staff of the Modeling Support Branch would have no other responsibilities. However, it is crucial that all staff members who participate in the support group perceive themselves as members of a distinct and important entity. Staff would need to participate in construction and implementation of a quality assurance plan for all support activities. They must also be able to see professional recognition for their work in this area.

The electronic bulletin board could be very important in the provision of centralized support services. The bulletin board would allow users to call at any time and describe their problem with the necessary depth of detail. Support staff would not have their work interrupted by answering the telephone calls. Instead, they could use specific blocks of time to get the questions from the bulletin board, determine the answer (using other expert sources if necessary), and post the answer to the user on the bulletin board. Users will receive a better quality answer, often in less time, than in the "telephone tag" approach.

The electronic bulletin board (or some other mechanism) should be used to log questions and answers. A database of previously answered questions would increase the ability of support staff to answer questions without further recourse to outside experts. When a question has been answered once and entered into the log, it is available for all other support personnel. Everyone then benefits from the collective experience. The log can also be used to gauge support activities for budget purposes and resource allocation.

4.6.1 Implementation Tasks

The following tasks are necessary to achieve the goal of centralized support. This plan is based on Battelle's experience in setting up similar support services to meet another client's needs.

The critical factor for support activities is the level of service given to users. Goals and standards for the necessary level of service must be determined. Standards could include time for initial response to user, time to solve the problem, frequency of referring the user elsewhere, and other related measures. Support Branch personnel should implement a quality assurance plan for all support activities.

Task 1: Plan for Support Group

- Define support scope and limitations including goals, schedule and resource requirements.
- Collect existing documentation, question/answer logs, list of outside experts, etc.
- Determine standards for support services, such as initial response time and time to solve the problem.

Task 2: Establish Support Group

- Set up electronic bulletin board for support services.
- Develop a user packet/marketing brochure to publicize the new services and tell modelers how to use them.
- Establish the question/answer log format.
- Obtain separate access to computers (IBM, VAX, PC).
- Obtain training on models and hardware as appropriate.

Task 3: Operate the Support Branch

- Respond to calls.
- Manage the question/answer log.
- Publish notes and notices.
- Initiate model software updates.
- Update documentation.

4.6.2 Estimated Costs and Time

Good user support obviously is worth some price. The primary constraint is staff resources. Current staffing levels are inadequate to handle any increased level of support. More staff time will be necessary. However, the time necessary to provide support would decrease as staff members become more expert in the new areas of knowledge and as the database of questions and answers grows. A support staff training program would also be necessary in the beginning which will increase start-up costs. Support staff should ideally be personnel with UNAMAP experience. The estimates of staff time are based on the assumption that the Model Support Branch will reside within the ASRL, and will be initially staffed by three persons (not full time). Three is the minimum recommended to assure coverage during all normal working hours, West Coast hours, vacations, etc.

Task 1: Staff time to plan

- 2 staff members for 2 months = 4 person-months

Task 2: Staff time to establish support system and receive training

- 2 staff members for 4 months
- 3 staff members for 2 months (training)
- Equipment costs: approx. $5,000 (PC, software, terminal)

Task 3: Staff time to operate

- 1.5 FTE per year

Establishment of centralized support will significantly change the focus of UNAMAP to a user-oriented system. Support staff will become more familiar with user concerns and problems and will document them in the log. These factors will increase the probability of correcting the problems in future models. The improved accessibility and ease of use of the support system will enhance the user's perception and use of UNAMAP.

4.7 Recommendation 7: Establish a Data Clearinghouse

Battelle recommends that EPA work with all data providers to facilitate the location and procurement of data by users. Dispersion models are useless without the data needed to simulate the meteorological conditions prevailing at or near the site in question. Providing a central source of information to assist in locating and procuring the data would bring improvement to one of the most difficult activities in the modeling process.

Facilitating access to data will advance the ease of use objective of the new UNAMAP. Providing data and models from a single source will also improve the view of UNAMAP's position as a single, unified source of information. Full consideration of the organizational and legal ramifications of this recommendation are beyond the scope of this study. Such issues will need resolution should EPA pursue the approach described below.

The electronic bulletin board could provide the medium to make the data clearinghouse a functional entity. Orders for data could be placed through the bulletin board to the data provider. After payment procedures are completed, the data would be downloaded through the system.

Data from the various sources may be handled differently in terms of ordering, payment and delivery. NWS data from NCDC could have the orders placed electronically. NCDC could then access the bulletin board, download the orders into their own system, and upload the data to the bulletin board or mail it out to the modeler. OAQPS provides some NWS data which has been preprocessed. This data is available on the EPA UNIVAC (the data will be moved to the IBM with rest of the UNAMAP system). A list of this data would be on the bulletin board. Users could place their order and have the data downloaded through the system. This would require a translation of the data tc ASCII coded characters. Onsite data would be handled differently. Persons with data could describe their data on the system. Users would contact the owner of the data, either via the bulletin board or by some other means. Buyers and owners would make purchase arrangements on an individual basis. The data could be mailed or sent through the bulletin board.

4.7.1 Implementation Tasks

Task 1: Collect information from data providers

- Get lists of data available, formats, locations, costs (if any)

Task 2: Set up bulletin board

A separate bulletin board area would have to be established to provide the data clearinghouse services.

- Develop bulletin board specifications for each different data source
- Establish the new bulletin board area

- Load data (if applicable)
- Test the new bulletin board and data files

Task 3: Publicize the service to users

- Prepare initial newsletter
- Produce user documentation for new bulletin board area

4.7.2 Estimated Costs and Time

This recommendation is estimated as an internal EPA task.

Task 1: Staff time

1 person for 3 months

Task 2: Staff time estimates for a single source are:

- Develop specifications = 16 hours
- Establish bulletin board area = 16 hours
- Load data files = 24 hours
- Test the bulletin board and data = 8 hours
- Estimated time: 15 calendar days

Task 3: Staff time

- Initial newsletter = 32 hours
- Bulletin board documentation = 40 hours
- Estimated time: 30 calendar days

4.8 Recommendation 8: Develop Specialized Models

Battelle recommends that EPA provide specialized models as part of the UNAMAP library to help the modeling community fulfill all aspects of their obligation to protect the environment. Specialized models will be designed for use in situations which are handled poorly or not at all by the current UNAMAP models. These models may need different modeling algorithms or new functions such as human exposure or health risk assessment.

UNAMAP has become the standard vehicle for dispersion modeling software, and the modeling community expects UNAMAP to continue to fulfill all their modeling requirements. UNAMAP's credibility, accessibility, and support system make it the obvious choice for the role of single-source modeling facility. Also, EOB's past record in responding to modeling needs has fostered the expectation that they will continue to provide new modeling services.

We have identified several types of models which are needed to meet current application requirements. These models are to handle such specialized situations as complex terrain, toxic gases, and offshore sites.

Development of the specialized models will involve both new model development and evaluation of existing models. The development of these models will require advances in modeling technology such as more intricate equations to adequately represent the complex situations being modeled.

The tasks required to develop these models are familiar to EPA. Some of the specialized models such as complex terrain are already under development by EPA. Others, such as offshore models, are within the purview of the EOB but not currently under development. Finally, toxic gas models are not currently in the scope of EOB work. If provided, they would need to be acquired.

4.9 Recommendation 9: Support the Collection of Additional and More Accurate Meteorological Data

Battelle recommends that EPA work closely with NWS, other government agencies, and industry to promote the collection and dissemination of meteorological data which will facilitate the advancement of dispersion modeling technology. Data may be the limiting factor in improving the accuracy of models in UNAMAP. Improvement in the data available will contribute to the goal of advancing research in modeling. Also, as data contributes to improved accuracy, it will increase the credibility of modeling to industry and the public.

4.9.1 Implementation Tasks

There are no specific quantifiable activities which will guarantee that improved meteorological data is captured. Rather, this recommendation is for EPA to press for data improvements through publicity, research, interagency agreements and regulatory changes. Some examples follow.

By increasing awareness throughout the air quality modeling community, EPA could increase public support for data collection improvements. Specific activities could include:

- Explanation of other countries' data collection techniques in talks and papers;
- Emphasis of improvements in model results when improved data is used;
- Analysis of cost-effectiveness (i.e., what economic benefits are derived by collection and utilization of improved data);
- Making modelers aware of availability of the best data and its utilization (an application for the data clearinghouse in Section 4.7).

A proportion of ASRL research could focus on the impact of data on model results. Some specific comparisons could include:

- Running the same model with on-site vs. NWS data, or with other specifications of atmospheric stability instead of current estimate;
- Comparing results of a model which utilizes improved data with a model which does not.

Increased cooperation with the government agencies responsible for meteorological data collection may eventually result in better data being available to UNAMAP modelers. In addition to NWS, approaches to NRC, DOE, and DoD may result in improved modeling data, at least for certain locations.

The Meteorology Division should continue to work closely with OAQPS to see that the best possible data is applied to modeling in the regulatory environment.

This may take the form of additions to the guideline models, or the allowance of modifications to certain models.

4.9.2 Estimated Costs and Time

The initiatives described above do not have a directly quantifiable cost or level of effort. They represent a certain direction in which to focus both research and management communication resources. Through our work on the UNAMAP evaluation, Battelle is aware that the resources of the Meteorology Division are extremely limited. Our interviews and questionnaire responses have highlighted the importance of this area, however, and we recommend that EPA implement some program to improve the data available for air quality modeling.

4.10 Recommendation 10: Support the Electronic Transfer of UNAMAP Documentation

Battelle recommends that EPA make UNAMAP documentation available to modelers through electronic file transfer. This would greatly speed the dissemination of documentation, both in the original form and for updates. The electronic documentation could be supported on the bulletin board system (See Section 4.1). Users could download a copy of any UNAMAP model's documentation whenever needed. Then, paper output and reproduction would be under the control of the user. Updates could be incorporated into the user's copy as needed.

This improvement directly promotes ease of use, and increases the extent of UNAMAP support offered through a central location. Indirectly, the use of non-regulatory models is facilitated through increased awareness and accessibility of their documentation.

4.10.1 Implementation Tasks

The key to the successful implementation of this recommendation will be the extent to which users can produce paper output of both text and graphics in a usable format. The challenge is to support the most common word processing and graphics systems that users may have. For this reason, the major effort associated with this improvement will be to develop the format specifications and any format conversion programs which may be required.

There are two alternative approaches. The first is to support one standard word processing format and one standard graphics package, most likely PC-based. Users would be required to acquire the standard packages. After downloading, they would use the standard packages' output drivers to produce paper copies on any printer or plotter supported by the packages. The other approach is to develop word processing and graphics "translator" software, and have it accessible to users. This software would "translate" the text and graphics documentation into one of several formats before downloading to the user.

Battelle recommends the former approach. Although some users would be required to buy additional PC software, this approach is much more affordable to EPA. Users would gain a valuable capability for a moderate (under $1000) price.

Task 1: Select standard graphics and word processing packages

- Evaluate capabilities of existing packages
- Determine current distribution in UNAMAP community
- Make Selection

Task 2: Publicize standards to users

- Distribute newsletter to users
- Put on bulletin board

4.10.2 Estimated Costs and Time

By using the approach which requires standard packages, the cost of this recommendation is minimized. If this recommendation is implemented in concert with the documentation changes in Section 4.2, the UNAMAP documentation will be revised and will then exist in some electronic form. This could be the standard format for electronic transfer. The costs attributable to this recommendation are then limited to selecting and publicizing the standard packages.

Task 1:

- o Labor for selection
  100 hours at $60 = $6,000
- o Copy of selected packages
  Word processing: approx. $500
  Graphics: approx. $500
- o Estimated time: 60 calendar days

Task 2:

- o Labor for publicity (newsletter and bulletin board)
  40 hours at $60 = $2,400
- o Estimated time: 20 calendar days

5.0 SCHEDULE

Battelle proposes a phased approach to the implementation of the recommendations. The implementation schedule has three phases:

Phase I:
- Establish an electronic bulletin board
- Provide UNAMAP code for multiple computers
- Produce end-user documentation
- Develop a set of user interfaces
- Support electronic transfer of documentation

Phase 2:
- Improve accuracy/technology of UNAMAP models
- Provide centralized support services
- Provide specialized models

Phase 3:
- Set up a data clearinghouse
- Support collection of meteorological data

The recommendations were assigned to specific phases based upon certain criteria. The first criterion is the breadth of impact upon UNAMAP users. Phase I activities are those which will have the most influence on the largest number of users.

The second criterion is the time and cost needed to implement the recommendations. These recommendations require little long-term planning or coordination outside the Meteorology Division. Therefore, the start-up time will be short for these activities, and actual work can begin quickly. Also, time and costs can be estimated with accuracy for these items. The preliminary tasks for Phases 2 and 3 have a long lead time. They need to be started during Phase 1 in order to facilitate their implementation in later phases.

The third criterion is ease of implementation. The recommendations in Phase 1 depend least upon the cooperation of sources outside of EOB. The actions needed to implement these improvements will be most easily handled since they are dependent upon a single entity and do not have to deal with the organizational issues inherent in multi-agency efforts.

The priority of implementation for the recommendations in Phase 1 is based on interdependence of the activities. The first priority is the electronic bulletin board. The bulletin board is an important mechanism used by many of the other recommendations. Providing UNAMAP for multiple computers is the second priority. Decisions made in the development of the new "universal" code are needed for later improvements. For example, ASCII disk-based input file specifications are part of the system requirements for the user interfaces. Production of end-user documentation is the fourth priority because documentation can only be completed after the previous activities. It will be possible to include the new services in the documentation rather than having to rewrite the manuals to include these services. Electronic transfer of the documentation will follow since the specifications needed for the transfer process cannot be written until the documentation is available.

5.1 Detailed Schedule for Phase I Tasks

The schedule for Phase 1, summarized below, makes assumptions based on staff resources at EOB. It is assumed that each task will be accomplished by no more than one professional staff member. Unless otherwise indicated, the time stated is based on one FTE staff member.

Priority 1: Establish an Electronic Bulletin Board:

Tasks 1 & 2 - Software evaluation and equipment procurement - can run concurrently

Task 3 - Implementation - cannot start until the other tasks are complete

Task 1:	Start:	Week 1	End:	Week 9
Task 2:	Start:	Week 1	End:	Week 9
Task 3:	Start:	Week 9	End:	Week 13

Priority 2: Provide UNAMAP Code for Multiple Computers
(See Section 4.3):

This schedule assumes two programmer/analysts. It also assumes that Task 1 is 80% of the time estimated in the first paragraph of Section 4.3.2.

Task 1: Start: Week 1 End: Week 24
Task 2: Start: Week 24 End: Week 28
Task 3: Start: Week 1 End: Week 28

Priority 3: Develop a Set of User Interfaces
(See Section 4.5):

This schedule is based on the assumption that one person will work on each task, but that tasks will overlap.

Task 1: Start: Week 28 End: Week 40
Task 2: Start: Week 36 End: Week 62
Task 3: Start: Week 41 End: Week 51
Task 4: Start: Week 52 End: Week 64

Priority 4: Produce End-User Documentation:

The schedule assumes that model documentation would be revised in the same sequence as interfaces are developed. Task 1 in this schedule is the first 12 models (six simple and six complex) as described in Section 4.5. Task 2 is the remaining 12 models. The schedule assumes that two persons will work on each task.

Task 1: Start: Week 63 End: Week 121
Task 2: Start: Week 65 End: Week 100

Priority 5: Support Electronic Transfer of Documentation
(See Section 4.10):

The schedule for this task is split, for the reason that the standard packages need to be determined before the documentation upgrades are begun, but the publicity of electronic transfer capability should be deferred until documentation is forthcoming. Note that the schedule for Task 2 is designed for incremental availability of electronic documentation. Task 2 should be complete when new documentation is available for the first model, i.e., ten weeks after the new documentation task is begun.

Task 1: Start: Week 54 End: Week 62
Task 2: Start: Week 73 End: Week 76

5.2 Budget and Schedule Summary for Phase I

The schedule for the Phase I recommendations is estimated to require 121 weeks, or approximately 28 calendar months. The schedule is shown graphically in the Gantt chart in Figure 2. The recommendations are shown in the chart in priority order.

A summary budget for Phase I is shown in Table 1. The figure lists each recommendation, its total estimated cost, and the estimated start time (in weeks after beginning implementation).

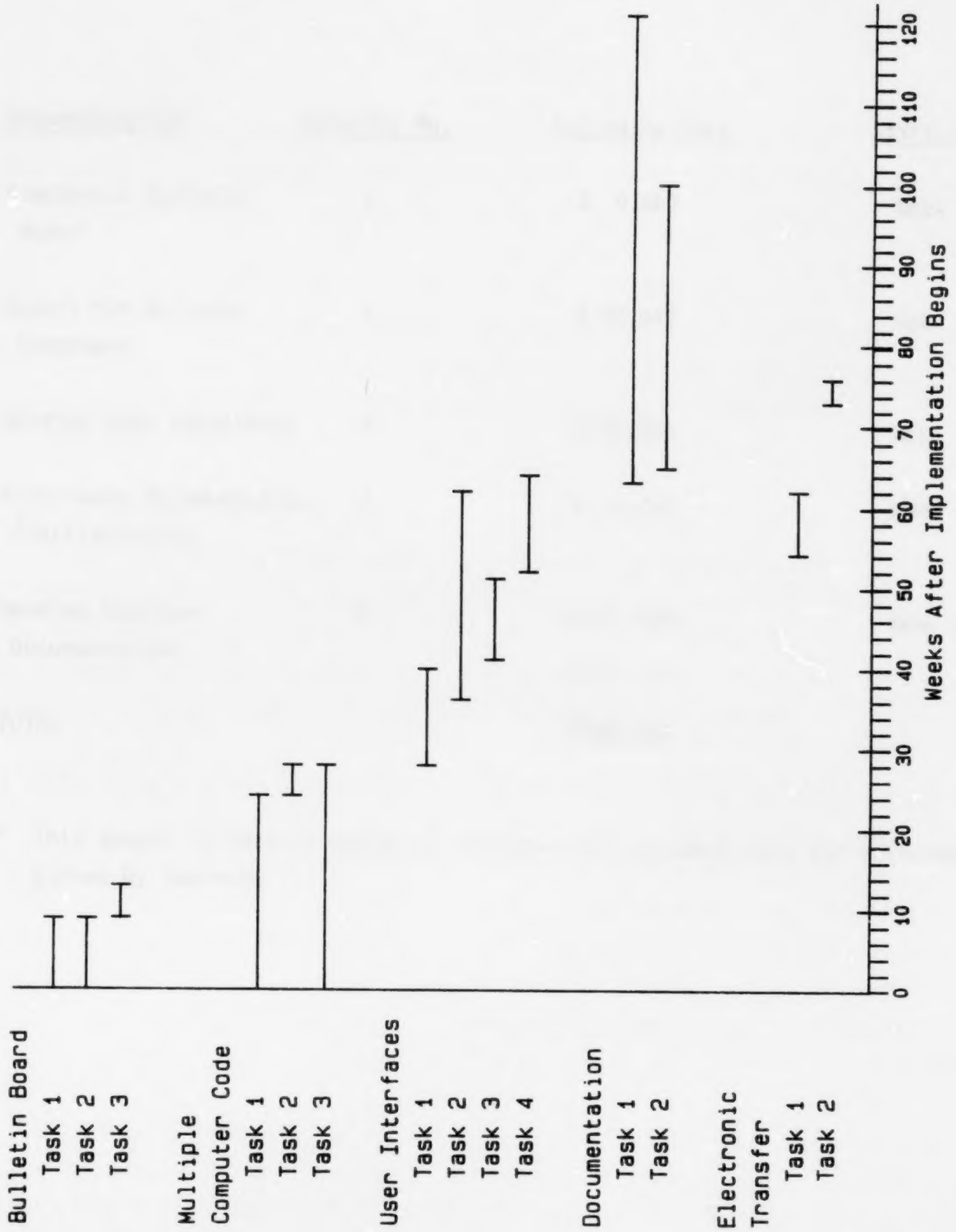

Figure 3. Schedule for Phase I Improvements

Recommendation	Priority No.	Estimated Cost	Start Time
Electronic Bulletin Board	1	$ 9,680	Week 1
Models for Multiple Computers	2	$ 90,040	Week 1
Develop User Interfaces	3	$ 99,000	Week 28
Distribute Documentation Electronically	4	$ 9,400	Week 54
Develop End-User Documentation	5	$561,000*	Week 63
TOTAL		$769,120	

* This amount is totally additive. No provision has been made for efficiency gained by learning.

Figure 4. Estimated Cost and Start Time for Each Phase I Recommendation Will Provide Timing of Funds Needed for Budget

6.0 SUMMARY

The results of the Evaluation and Assessment of UNAMAP project will facilitate EPA's efforts to improve UNAMAP. This report is the last of four major parts of Battelle's project.

The report described a plan for implementing a series of recommended improvements to the UNAMAP program. The plan consists of a strategy to attain EPA's long-range objectives for UNAMAP, the specific improvements which are recommended by Battelle, and the schedule and budget to implement the recommendations.

The conclusions reached in this report were based on research and analysis which were performed in three earlier phases of the project. The first was a technology assessment to determine technology available to UNAMAP. The second was data collection (by interview and questionnaire) and analysis. The third was formulation of recommendations. These three phases were summarized in this report to give the reader the necessary background information.

The ASRL Meteorology Division's major objectives for UNAMAP are to advance research in dispersion modeling and to transfer the technology to the public. Because these two objectives are interdependent, Battelle's strategy for improving UNAMAP considered both. Changes have occurred in the UNAMAP user community, and in the UNAMAP software library itself since the UNAMAP was begun. Battelle's research results indicate that these changes have resulted in a reduced effectiveness of the UNAMAP program in meeting its two objectives.

The report described the implementation of specific recommended improvements which will promote the increased effectiveness of UNAMAP. The recommendations were designed to support the long-range objectives of the UNAMAP program and remedy the underlying causes of current problems. Achievement of the strategic objectives will help UNAMAP continue to fulfill its leadership role in air quality modeling.

Based on interdependence of recommendation and on breadth of benefit, Battelle divided recommendations into three phases for implementation. The recommendations in each of the three phases are:

Phase I:

- Establish an electronic bulletin board
- Provide UNAMAP code for multiple computers
- Produce end-user documentation
- Develop a set of user interfaces
- Support electronic transfer of documentation

Phase 2:

- Improve accuracy/technology of UNAMAP models
- Provide centralized support services
- Provide specialized models

Phase 3:

- Set up a data clearinghouse
- Support collection of meteorological data

The schedule developed indicates that the Phase 1 recommendations can be implemented, with a relatively low level of effort, within 26 months. After that time, UNAMAP will have advanced a great distance toward becoming the air quality modeling service with both well-researched models and a strong user orientation.

APPENDIX A:

UNAMAP USER DOCUMENTATION
RECOMMENDED FORMAT

The following annotated outline identifies a general plan for the major sections of the proposed revised UNAMAP documentation.

UNAMAP Documentation
XYZ Model

Section Title	Description
Note to Readers	Includes an identification of the various types of readers/users and presents a road map to the various sections. Purpose: To show each reader what parts of the documentation will be useful to them, depending on their unique needs.
Overview	Presents background on the model including any key terms and concepts; features and limitations; and a brief, but complete technical description which identifies assumptions used in the model. Purpose: To provide all readers with a context for applying the model.
Tutorial	Provides a step-by-step introduction to the actual use of the model. Steps the user through several examples. Identifies techniques used in the model, such as menu options, prompts, commands, etc. Introduces any major points related to use of the model. Where appropriate, relates to reference material in the subsequent sections.

	Purpose: To provide a first-use experience to all types of users.
Reference/Job Aids	Includes reference material such as menu illustrations, diagrams, and option descriptions; prompts and acceptable/unacceptable responses; data field limitations and restrictions; data collection and data entry job aids; and other checklists. Also includes sample model output with explanation to assist users in reading output. Purpose: To provide functional reference aids to assist all types of users in the actual use of the model.
Scientific Notes	Additional reference material of a scientific and/or meteorological nature, such as scientific modeling concepts, sensitivity analyses, or point source computations. Purpose: To satisfy additional informational requirements of dispersion meteorologists and others interested in the scientific foundations of the model.
Program Notes	Additional reference material of a computer programming nature, such as the program overview and structure, indexed listing of the FORTRAN source statements, and other programming details. Purpose: To satisfy additional informational requirements of data processing personnel and

	others interested in the computer programming aspects of the model.
Glossary	Brief but complete definitions of technical vocabulary used in the model, the documentation, or the output. Purpose: To provide ready reference on technical terms users might encounter in working with the model.

To further illustrate this design, the following diagram shows how the current table of contents for the PTPLU model documentation would be reorganized around this new design concept.

PTPLU Model
Comparison of Current Table of Contents and Proposed Revised Organization

Note: Items that appear in bold in the right column indicate sections of content that already exist in the current documentation. In some cases, these will require some reformatting and new presentations. Other items listed in the right column are new material.

Current Documentation

- Foreword
- Preface
- Abstract
- Figures
- Symbols and Abbreviations
- Acknowledgments
- 1. Introduction
- 2. Data Requirements Checklist
- 3. Features and Limitations
- 4. Technical Description
- 5. Program Overview and Structure
- 6. Input Data Preparation
- 7. Execution of the Model and Sample Test
- 8. Example Calculation
- References
- Appendices
  - A. Modeling Concepts
  - B. Indexed Listing of FORTRAN Source Statements
  - C. Sensitivity Analysis
- Glossary

Proposed Revised Organization

- Foreword
- Note to Readers
  - **abstract**
  - **preface**
- Table of Contents, List of Figures, List of Tables
- Overview
  - **introduction**
  - terms and concepts
  - **features and limitations**
  - **technical description**
- Tutorial
  - tutorial demonstration
  - **execution of the model and sample test**
  - **example calculation**
- Reference/Job Aids
  - **data requirements checklist**
  - **input data preparation**
  - **symbols and abbreviations**
  - menu organization and use
  - prompts and responses
  - sample output with explanation
- Scientific Notes
  - **modeling concepts**
  - **sensitivity analysis**
- Program Notes
  - **program overview and structure**
  - **indexed listing of FORTRAN source statements**
- Glossary
  - **glossary**